

EXPLORE MUSLIM HERITAGE IN OUR WORLD...

WHILE THE WEST
STRUGGLED IN A PERIOD
CALLED THE DARK AGES, A
**GOLDEN AGE
OF MUSLIM
CIVILIZATION**
BROUGHT SCIENCE,
TECHNOLOGY, AND
INNOVATION INTO THE
SPOTLIGHT—AND WE SEE
IT EVERY DAY!

"I am delighted to see
the success of **1001
INVENTIONS**, which
presents and celebrates
the many scientific,
technological and
humanitarian developments
shared by the Islamic world
and the West."

—His Royal Highness Prince
Charles, The Prince of Wales

THIS BOOK IS BURSTING WITH **AMAZING FUN
FACTS** FROM HISTORY AND MODERN DAY!

- MORE THAN 1,001 FASCINATING FACTS!
- PACKED WITH 400 EYE-CATCHING PHOTOGRAPHS AND A
HIGHLY VISUAL DESIGN THAT BRINGS HISTORY TO LIFE

COFFEE WAS
DISCOVERED BY A
GOAT HERDER IN ETHIOPIA;
PEOPLE IN MUSLIM SPAIN
WORE **HIGH HEELS**;
INVENTORS CREATED
COMPLEX CLOCKS
POWERED BY
WATER AND PERFECTED
**SURGICAL
TOOLS**; MOST MUSLIM
HOMES HAD AIR
CONDITIONING; PLUS
PERFUME,
TOOTHPASTE,
AND MORE CAME FROM
MUSLIM CIVILIZATION.



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1001

INVENTIONS & AWESOME
FACTS
FROM MUSLIM CIVILIZATION



NATIONAL
GEOGRAPHIC
WASHINGTON, D.C.

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FOREWORD

Imagine a time and place where people from different countries, cultures, religions, and backgrounds work together to discover new knowledge, understand more about the world, and develop new inventions while sharing them openly and freely. A world in which the common language is science and that language is used for the benefit of everyone. A world in which progress is based on the sharing of ideas and working collaboratively.

Such a time and place existed. It was a long time ago and has almost been forgotten.

1001 Inventions & Awesome Facts from Muslim Civilization takes you to that world and introduces you to some of the men and women who helped form the basis of much of modern science, technology, medicine, and the understanding of our world. These men and women studied science from previous civilizations and other cultures under the umbrella of Muslim culture and civilization. They built upon this knowledge and in turn passed the achievements on to the modern world. These important advancements took place during medieval times, or what some call “the Middle Ages.” It was a time when it seemed there was little to no innovation happening. But in Muslim civilization, which stretched from Spain to China, the period was known as “the Golden Age.”

More than 300 years ago, the great Sir Isaac Newton remarked that if he had seen farther than others, it was because he was standing on the shoulders of

giants. This expression of humility, and of appreciation for our predecessors, has been repeated by hundreds of scientists, scholars, engineers, and inventors ever since. In this book you will meet some of those “giants”: scholars, scientists, inventors, engineers, architects, explorers, medical specialists, astronomers, and teachers. Their developments and achievements still touch our modern lives.

The initiative *1001 Inventions* brings this underappreciated time and place to life. *1001 Inventions* has a powerful and fascinating story to tell, since the influence of Muslim heritage can be found today in our homes, schools, hospitals, farms, supermarkets, airports, parks, and gardens in countless ways.

Millions of people around the world have experienced *1001 Inventions*, through interactive exhibitions, best-selling books, and the award-winning movie *Library of Secrets*, starring Oscar winner Sir Ben Kingsley, which has been downloaded more than 20 million times.

This new book, published by National Geographic in partnership with the Foundation for Science, Technology and Civilisation, introduces more than 1,001 amazing facts about inventions from the Golden Age. I sincerely hope it will amaze and inspire you to stand on the shoulders of giants yourselves to see farther than anyone has ever done before.

Professor Salim Al-Hassani
Chief Editor and Chairman, FSTC

10

FAST FACTS

YOU NEED TO KNOW ABOUT

1

We often think that people from a thousand years ago were living in the "Dark Ages." But in **MUSLIM CIVILIZATION** from the 7th century onward there were amazing advances and inventions

THAT STILL INFLUENCE OUR EVERYDAY LIVES.

2

PEOPLE LIVING IN THE MUSLIM WORLD SAW WHAT THE **EGYPTIANS, CHINESE, INDIANS, GREEKS, AND ROMANS** HAD DISCOVERED AND SPENT THE NEXT **ONE THOUSAND YEARS** ADDING NEW DEVELOPMENTS AND IDEAS.

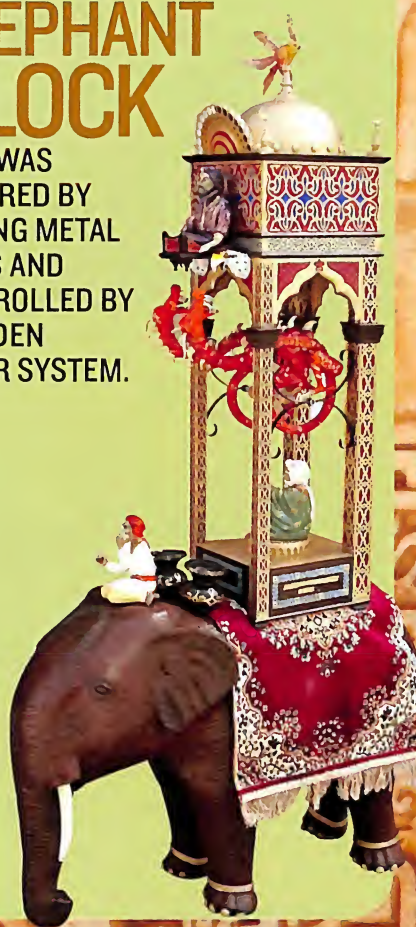
3

EXPLORERS DREW DETAILED **MAPS**, INCLUDING THE EARLIEST MAP SHOWING AMERICA, SAILED THE HIGH SEAS, AND TOOK THE FIRST GIRAFFE TO CHINA.

4

ENGINEERS IN THE MUSLIM WORLD DESIGNED INTRIGUING MACHINES, INCLUDING A MECHANICAL **ELEPHANT CLOCK**

THAT WAS POWERED BY FALLING METAL BALLS AND CONTROLLED BY A HIDDEN WATER SYSTEM.



5

NEW FOODS LIKE **APRICOTS, ORANGES, AND RICE**

SPREAD FAR AND WIDE, AND FARMERS USED PUMPS TO WATER CROPS AND WINDMILLS TO GRIND PRODUCE.



6

ARABIC BOOKS WERE TRANSLATED INTO LATIN. THE SHARED KNOWLEDGE HELPED BRING ABOUT A NEW RUSH OF DEVELOPMENT IN EUROPE.

MUSLIM CIVILIZATION

7

A WOMAN NAMED FATIMA AL-FIHRI

founded the world's first university, where you can still study today. People also made breakthroughs in chemistry, physics, and mathematics.



9

ARCHITECTS BUILT DOMES LARGER THAN EVER BEFORE AND DESIGNED DISTINCTIVE ARCHES AND TILE PATTERNS.



8

Doctors could treat all kinds of diseases, fix your broken leg, give you an eye operation, and stitch you up after surgery using CATGUT.



10

ASTRONOMERS MAPPED THE STARS AND GAVE SOME OF THEM NAMES WE STILL USE. ONE EVEN MENTIONED THE GALAXY WE NOW CALL ANDROMEDA. OTHERS WORKED OUT HOW TO PREDICT THE MOON'S PHASES AND LUNAR AND SOLAR ECLIPSES.

Decorative Arabic reliefs and tiles in Nasrid Palace, in present-day Granada, Spain

THE GOLDEN AGE OF

WINGED FLIGHT

'Abbas ibn Firnas experimented with flying using a form of glider. (pages 30–31)



SELIMIYE MOSQUE

Mimar Sinan became famous in 16th-century Turkey for designing taller and wider domed roofs than ever before. (pages 52–53)



MECHANICAL CLOCKS

Al-Jazari's Elephant Clock is an example of the ingenious mechanical devices created during this golden age. (pages 38–39)



SURGICAL INSTRUMENTS

As far back as the 10th century, doctors in the Muslim world worked with surgical tools. Some look similar to those we use today. (pages 46–47)



AL-IDRISI'S WORLD MAP

Long before Christopher Columbus set sail, Muslim scholar Al-Idrisi created an atlas showing Europe, Asia, and North Africa. (pages 62–63)



OLDEST UNIVERSITY

Fatima al-Fihri financed and supervised the building of the Al-Qarawiyyin mosque in Fez, Morocco, 1,150 years ago that is now the world's oldest active university. (pages 16–17)



CAMERA OBSCURA

Ibn al-Haytham's experiments with light in a dark room ("camera obscura" in Latin) paved the way for modern cameras. (pages 34–35)



COFFEE

A 9th-century Abyssinian saw eating coffee beans energized his goats. Demand for the beans made Mocha, in Yemen, the chief trading port. (pages 80–81)



MUSLIM CIVILIZATION 7TH TO 17TH CENTURIES

ASTROLABES

"Merriam" al-Astrulabiya was skilled at making very accurate astrolabes, complex gadgets for finding directions, telling time, and observing the sun and stars. (pages 24–25)



Welcome to the Golden Age of Muslim civilization, during which men and women of different faiths and cultures worked together to create thousands of inventions and discoveries that changed the world. Stretching over three continents, from Spain and northern Africa through the Middle East to Indonesia and China, Muslim civilization contributed to advances in science, mathematics, medicine, technology, architecture, and more. Check out the map for highlights of things invented or discovered in this period.

HOUSE OF WISDOM

In the early 9th century the top scientists and scholars from many regions of the Muslim world gathered at the House of Wisdom to study, debate, and make new discoveries. (pages 32–33)



MAP KEY

- Lands under Muslim control at various times from the 7th century onward
- Point of interest
- Other city

ZHENG HE'S WOODEN SHIPS

Zheng He became admiral of the Chinese fleet, sailing in the early 1400s the biggest wooden ships the world had ever seen. (pages 64–65)



WINDMILLS

Five hundred years before windmills appeared in Europe, they were a common sight in parts of the Muslim world. (pages 84–85)



DISTILLATION

Jabir ibn Hayyan perfected the distillation process, which is still used in the creation of perfume, gasoline, plastics, and more. (pages 20–21)



15

TERRIFIC FACTS

1 You might be surprised to learn that many of the **conveniences** and **comforts** that you enjoy today were part of the everyday lives of people living in Muslim civilization a thousand years ago.



2 Towns in Muslim **civilization** were highly advanced and organized for their time. The main features, like markets, homes, bathhouses, and parks, were neatly arranged around a mosque.

3 Most **homes** in Muslim civilization had built-in air-conditioning, inner courtyards, gardens, and terraces. By contrast, most people in medieval cities elsewhere lived in far less comfortable **dwellings**.



4 Walls around houses had to be **taller** than the height of a **camel rider** to protect the privacy of the people inside.



5 To provide **relief** from the hot, desert climate, town planners created **shade** by designing narrow, covered streets, indoor and outdoor fountains, and courtyards with elaborate gardens.

6 People of different **faiths and ethnic backgrounds** lived near each other and worked together in towns under Muslim rule.

7 Shopping for food, spices, books, and other goods was done at an open-air market called a **souk**.



8 People still shop at **souks** in **Morocco, Turkey**, and other **Muslim countries**.



ABOUT TOWNS

9 Homes in Muslim neighborhoods had to be built within earshot of the **muezzin's call** to prayer from the mosque.



10 Córdoba, in Muslim Spain, was the **New York City** of the 9th- and 10th-century world. It featured free schools, libraries, houses with running water, and much more.

11 The fountains of the **Alhambra Palace** in Granada, Spain, still use the 650-year-old water system designed during Muslim rule.

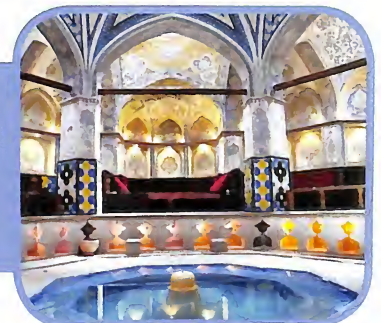
12 In contrast to Córdoba, London, England, and Paris, France, didn't have oil-burning **street-lights** and **paved roads** for another several hundred years.



13 In some more advanced towns, trash was collected regularly by a **donkey cart**, and streets were cleaned daily and drained by a system of sewers.

14 **Hammams**, or bathhouses, were an important part of towns in Muslim civilization.

15 Townspeople spent a part of certain days at the **hammam**, relaxing in its **steam room**, taking a hot bath, or plunging into a cold pool.



Kalyan Mosque, Bukhara, Uzbekistan



15

FACTS ABOUT GARDENS



1 In Muslim civilization gardens were a symbol of an **earthly Paradise** and a perfect place to sit and think.

2 Beginning in the 8th century the **designing** and **planting of gardens** spread across the Muslim world from Spain to India.

3 Numerous references in the Quran to Paradise gardens, like **Eden**, influenced designers.



4 In the 10th century gardens began to include **shallow canals** and **fountains** and flower beds arranged in **geometric patterns**.



5 You can still see such **gardens at the Taj Mahal in India**, at the Alhambra in Spain, and elsewhere in Europe, where formal gardens designed with similar features were created centuries later.

6 **Water was scarce** in much of the Muslim world, so garden fountains and canals were the **ultimate display of wealth**.

7 Muslim engineers invented **ingenious ways** to control the display and flow of water in garden fountains so the fountains would be both **beautiful** to look at and **soothing** to listen to.



THAT WILL GROW ON YOU



Longwood Gardens,
Pennsylvania, U.S.A.

8 The **12 lions** around a garden fountain at the **Alhambra** in Spain formed a water clock when they were created 650 years ago. Back then, water spouted from the mouth of a different lion each hour.



9 Flowers such as **tulips**, **irises**, and **carnations** all made their way from Muslim civilization to Europe and beyond.

10 Gardens also were used for **botanical experiments**, providing shade, and growing food.

11 Glass rooms called “**conservatories**” evolved from Turkish kiosks, or **koshks**, and later were added to homes in Europe and elsewhere.



12 A **koshk** was a domed hall with open, arched sides. **Bandstands and pavilions** in city parks today trace back to them.

13 In Muslim civilization **koshks** were usually **attached to a mosque** and often **overlooked gardens**.

14 Gardens even inspired their own kind of Arabic poetry called **rawdhiya**.

15 One of the most famous kiosks, **Cinili Koshk**, was built in 1473 at Topkapi Palace in Istanbul, Turkey. **It is two stories tall and topped with a dome.**



1 **EVERYONE**
in the Muslim world
wanted to
LEARN NEW THINGS
and share their discoveries.

4 By the **LATE 9TH CENTURY**
almost every mosque had an
ELEMENTARY SCHOOL
for boys and girls.

2 **A THIRST for
KNOWLEDGE**
LED TO THE FIRST SCHOOL,
ESTABLISHED IN A MOSQUE IN
MEDINA IN WHAT IS NOW SAUDI
ARABIA IN **622**.



3 Traveling teachers, known
as **AHL AL-'ILM**
("THE PEOPLE WITH
KNOWLEDGE"), helped
spread learning to
other Muslim towns
and cities.



5 ACCORDING TO IBN HAWQAL, A TRAVEL-
ING GEOGRAPHER, **THE CITY OF
PALERMO**, IN MUSLIM SICILY,
IN THE LATE 10TH CENTURY HAD
300 MOSQUES
THAT TAUGHT VARIOUS SUBJECTS.

25

SMART FACTS



6 Kids began school at the
AGE OF SIX, much as they do now.

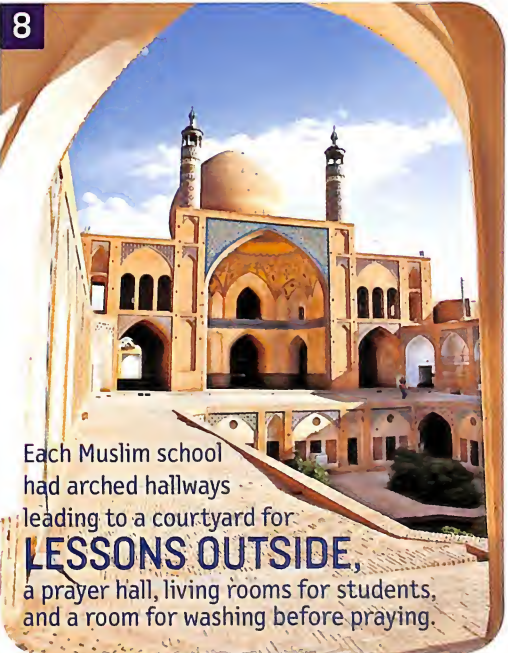
7 Among the early
skills schoolchildren
learned were how to
write verses from
the Quran and the
**99 NAMES
OF ALLAH**
(God).



9 Students learned mostly through
**REPETITION and
MEMORIZATION**.
Today many Muslim students
still memorize all 6,239 verses of
the Quran.



10 Wealthy people
HIRED TUTORS
to teach their
children in
their **HOMES**.



8 Each Muslim school
had arched hallways
leading to a courtyard for
LESSONS OUTSIDE,
a prayer hall, living rooms for students,
and a room for washing before praying.

11 **IN 1066**
THE FIRST
MADRASA,
A SCHOOL
SEPARATE
FROM A MOSQUE,
WAS BUILT IN
BAGHDAD.

12 Classroom
time was
**SUPER
SERIOUS**
—no talking,
laughing,
or joking!

13 There were **FOUR
DIFFERENT KINDS
OF MUSLIM SCHOOLS**:
regular (primary) schools,
houses of readers (high schools),
houses of *hadiths* (religious schools),
and medical schools.

14 Most schools had
LIBRARIES
filled with books
written in Arabic
on **ADVANCED
TOPICS** like
chemistry, physics,
and astronomy.



15

EDUCATION IN MUSLIM CIVILIZATION WAS FREE,

and some students were provided with books, pocket money, and a place to live.



16

FUNDS CALLED AWQAF

were set up to build schools and to pay for things like teachers' salaries and meals for students.



18

A quest for **ADVANCED EDUCATION** among scholars of the Muslim world led to the spread of universities—ultimately sparking **A REVIVAL OF LEARNING** throughout Europe.

17

By the 15th century, THE OTTOMANS REVOLUTIONIZED SCHOOLS

by setting up a kind of learning center called a **KULLIYE**.

Each complex had a mosque, school, hospital, and dining area.



ABOUT

SCHOOLS

19

"UNIVERSITY" IN ARABIC IS JAMI'AH, AND THE WORD FOR "MOSQUE" IS JAMI'. In early Muslim civilization, many scholars saw a clear connection between learning and faith.

20

The **MOST SOUTHERLY** of the big universities was in **TIMBUKTU IN MALI, WEST AFRICA**. By the 12th century it had about **25,000 STUDENTS**.



21

FATIMA AL-FIHRI

used her fortune and talent to build a mosque with a school called Al-Qarawiyyin in Fez, Morocco. It is now the

WORLD'S OLDEST ACTIVE UNIVERSITY.

You can still study there today.



22

SOME SCHOOLS ATTACHED TO MOSQUES IN THE MEDIEVAL MUSLIM WORLD ARE CONSIDERED TO BE THE WORLD'S OLDEST UNIVERSITIES.

24

Much **LIKE COLLEGE KIDS TODAY**, students at universities in the Muslim world took **ENTRANCE EXAMS**, **JOINED STUDY GROUPS**, and **HAD TO PASS FINAL EXAMS TO GRADUATE.**

25



EUROPEAN STUDENTS TRAVELED TO AND FROM MUSLIM CITIES TO STUDY AT COLLEGES AND TO LEARN ARABIC, CONTRIBUTING TO THE SPREAD OF ISLAMIC KNOWLEDGE, IDEAS, AND STYLES.

AL-QARAWIYIN was equipped with high-tech gear for the time, such as astronomy instruments, astrolabes, sundials, and sand and water clocks. Students calculated time in a "timers room," supervised by Al-Muwaqqit ("the timekeeper").

23

15

HEAD-TURNING



1 Baghdad was the **Paris** of the **9th century**.

2 Popular fashions like **high-heeled shoes** and **lightweight pants** for summer first came on to the scene in Muslim Spain more than a thousand years ago.

3 **Ziryab**, a famous 8th- to 9th-century musician and stylist from Baghdad, sparked a fashion movement in the Muslim world when he moved to Córdoba, in **Muslim Spain**.



4 Ziryab was a major trendsetter of his time, influencing everything from **hairstyles** to clothing styles.



5 As students left Córdoba, they took with them the **trends** pioneered by Ziryab, eventually spreading them throughout **Europe and North Africa**.

6 People in Muslim Spain began to follow a **fashion calendar**, changing their **styles** based on the season like we do now.



7 They'd wear brightly colored clothes made of cotton, silk, and flax in the **hot season**, then change to warm, dark wools and cottons for **winter**.



Traditional leather slippers at a souk in Morocco

FASHION FACTS



8 **Women** in Muslim Spain went from wearing their hair in a single braid down the back to a bolder, shorter cut with bangs.



9 **Men** began shaving their beards—a nod to Ziryab's clean-cut look.

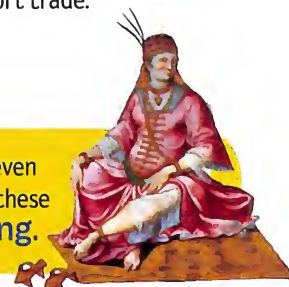
10 Ziryab opened a **salon** and **cosmetology school** close to Alcazar, the emir's palace in Córdoba, Spain.

11 Today there is a street, a hotel, a club, or a cafe named after Ziryab in **every country** in the Muslim world.



12 Leather and cork-soled **sandals** became all the rage in Muslim Spain and a staple of the export trade.

13 Two **medieval** Muslim writers even penned a book detailing how to make these sandals, down to the specific **stitching**.



14 Some **shoemakers** put sand below the heel to make it higher and to act as a shock absorber, creating one of the earliest forms of **high heels**.

15 Today's global Muslim **fashion industry** is estimated to be worth around **\$96 billion**.



1

Medieval times are often imagined as **SMELLY**, dark, and unclean, but in 10th-century Muslim civilization people were very concerned about hygiene.

2

The **COSMETIC PRODUCTS** used in Muslim civilization a thousand years ago could almost compete with those we have today.

3

Cleanliness is vital in Islam, and **WUDHU'**—washing parts of the body—is always done before prayers.

4

According to the Quran, a Muslim **MUST WASH** face, hands, head, and feet **BEFORE PRAYING**.

5

A 13th-century **ROBOTIC wudhu'** machine that looked like a **PEACOCK** shot eight spurts of water from its head—just enough to wash with.

6

Other machines even **HANDED YOU A TOWEL** to dry off!

7

To make **SOAP**, a mixture of oil, *al-qali* (a salt-like substance), and sweet- or spicy-smelling ingredients was **BOILED** and left to harden in a mold.

8

Lye (sodium hydroxide), perfumed and colored soaps, and liquid and solid soaps also were made by **CHEMISTS** in the Muslim world.

9

MEDIEVAL MUSLIMS went to great lengths to keep up their appearance.

10

AL-ZAHRAWI, a physician and surgeon from Muslim Spain, wrote about hair and skin care, **TEETH WHITENING**, and gum strengthening.

11

He considered cosmetics to be a branch of medicine that he called **"MEDICINE OF BEAUTY."**

12

Al-Zahrawi also wrote about **NASAL SPRAYS**, mouthwashes, and hand creams.

13

Recipes for **BREATH FRESHENERS** date back to ancient times and include ingredients such as charcoal, fruit, and dried flowers.

14

Al-Zahrawi's concept of molded perfumed sticks may be the earliest versions of **LIPSTICK** and roll-on deodorant.

15

The benefits of **SUNSCREEN** were also discussed by Al-Zahrawi.

16

Al-Zahrawi suggested **HAIR-REMOVING STICKS**, hair dyes that turned blond hair to black, and lotions for straightening curly hair.

17

AL-KINDI, a scholar from Iraq, wrote a book on perfumes. It was **PACKED WITH RECIPES** for fragrant oils, creams, and scented waters.

18

Al-Kindi's book also described **107 METHODS** and recipes for perfume making and perfume-making equipment.

19

At first only **WEALTHY PEOPLE** used perfumes, but later they became more available to all.

20

The **ALEMBIC**, a glass container used in distillation, still bears its Arabic name.

21

Chemists made **PERFUMES** by distilling plants and flowers. Some of these ingredients, like jasmine and citrus fruits, are still used in perfumes.

22

Muslims also used **HERBS AND SPICES** to make perfume.

23

The knowledge about perfumes made its way from the Muslim world to southern **FRANCE**, which had the perfect climate and soil for perfume making.

24

Southern France's perfume industry continues to thrive, **700 YEARS LATER**.

25

Every single day **170,000 BOTTLES** of perfume are sold in France alone.

26

In 2006 a **HALF-OUNCE BOTTLE** of a particular perfume was sold to a wealthy client for **\$234,450**.

27

According to tradition, the Prophet Muhammad scrubbed his teeth with a twig of **miswak** before each prayer time. Its use is still popular.

28

More than **1,000 YEARS** ago, the Muslim musician and fashion icon **ZIRYAB**, **"THE BLACKBIRD,"** introduced toothpaste to Andalus.

29

The **EXACT INGREDIENTS** of Ziryab's toothpaste are unknown, but it was said to have been both "functional and pleasant to taste."

30

Today more than **ONE BILLION TUBES** of toothpaste are purchased each year just in the United States.

31

Ziryab also introduced the **USE OF SALT** to clean clothes.

32

Muslim methods and ideas about hygiene **FILTERED INTO EUROPE BY WAY OF MERCHANTS**, travelers, and Crusaders.



33

In keeping with the Islamic tradition of cleanliness, the **HAMMAM**, or bathhouse, became an institution in every Muslim town.

36

It's still customary in many parts of the Muslim world for a **BRIDE-TO-BE** to be groomed at a *hammam* before her wedding.



39

PUBLIC BATHS made a comeback in Europe in the 17th century after tourists raved about Turkish baths.

42

There was a **TURKISH BATH** on the doomed R.M.S. *Titanic*.



45

At Mahomed's **INDIAN VAPOR BATHS**, clients sat in flannel tents and were given a massage by a person reaching in through slits in the flannel.

46

HENNA, the reddish-brown herbal paste commonly used to create elegant designs on women's hands, has been used as a hair dye for 6,000 years.

47

Men used henna to **DYE THEIR BEARDS**, following the tradition of the Prophet Muhammad.

48

Henna, which is **ANTIBACTERIAL** and antifungal, is used to treat rashes.

49

Henna is also a natural **HAIR CONDITIONER**.

50

In 2011 a woman in India set a world record by **DECORATING 170 HANDS** with henna in just over 24 hours!



50

Fresh Facts ABOUT KEEPING CLEAN

34

The *hammam* brought friends, neighbors, relatives, and workers together regularly to **RELAX** and **CATCH UP**.

35

Bathhouses were used by men and women but at **SEPARATE TIMES**. Women usually bathed during the day and men at night or very early in the morning.

37

The *hammam* is believed to be the origin of most **MODERN HEALTH** and fitness clubs around the world.

38

Hammams had **STRICT RULES**. Men had to keep their lower half covered, and women were forbidden to enter the *hammam* if men were present.



40

The first **TURKISH BATH** in Europe, called a **BAGNIO**, opened as early as 1679 in London, England. Others were built in Scotland.

41

Picking up on Muslim style, Turkish baths were **DOMED BUILDINGS** with horseshoe arches and geometrical lattice windows.

43

Some *hammams* from **THE MEDIEVAL MUSLIM ERA** are still in use in places like Morocco and Turkey.

44

In the late 1700s the Indian Sake Dean Mahomed opened a bathhouse in England and became known as the **"SHAMPOOING SURGEON."**

15

PLAYFUL FACTS



1 Chess **developed** more than a thousand years ago—so long ago that we don't know if it began in India or Persia.

2 An Icelandic story tells of the Danish king **Knut the Great** playing chess in 1027.

3 Chess may be based on the Indian game *Chaturanga*, which means “**having four limbs**”—a likely reference to India's army, which had four branches: soldiers, horsemen, chariots, and elephants.

4 Persians changed the name to *Chatrang* and used it in **war games**.



5 At the time, the playing pieces were *Shah* (the king); *Firzan* (a general, who became the **queen** in modern games); *Fil* (an **elephant** that is now the bishop); *Faras* (Arabic for “horse”); *Rukh* (a **chariot** that is now the castle, or rook); and *Baidaq* (the **pawn**).

6 A 13th-century manuscript from Spain shows **women playing chess**.



7 The **rules** of chess have not changed in nearly 500 years.

8 There are **169,518,829,100,544,000,000,000,000,000** ways to play the first ten moves in chess.



ABOUT CHESS



Chessboard

9 Travelers going from Persia to Spain took the game with them and **introduced chess to Europe**.

10 A Russian chess champion won a match with a move used by the Arab master **Al-Suli** 1,000 years ago.



11 The word "**checkmate**" comes from the Persian word **Shahmat**, meaning "the king is dead."

12 In the 18th and 19th centuries people traveled miles to watch the "**Iron Muslim**," a chess-playing robot whose moves were actually made by a chess master hiding below the board.



13 Fifteen different chess masters operated the "Iron Muslim" during its **85-year reign** over other top players of the day.



14 Today chess is played everywhere. About **three million chess sets** are sold every year in the United States alone.

15 Two German men set a record in 2010 for the **longest** chess game to date: 40 hours and 20 minutes.



1 The study of astronomy in the Muslim world included scholars from many countries and cultures.

2 Keeping a close watch on the sky helped Muslims find the direction of Mecca.

3 The Quran encourages the exploration of the universe.

4 Muslim civilization was the first to use observatories and large instruments to study the heavens.

5 WORKING IN TEAMS LET ASTRONOMERS STUDY PLANETS AND STARS IN MORE DETAIL THAN EVER BEFORE.

6 The Toledan Tables are astronomical charts that predict the movements of the moon, sun, and planets and take their name from Toledo, a city in Muslim Spain.

7 The tables were written in the 9th century by Al-Zarqali, known in Europe as Arzachel.

8 For 300 years Muslim-ruled Toledo was the world's center for astronomy and science.

9 Caliph Al-Ma'mun set up a government-funded observatory in Baghdad so astronomers could work together in one place.

10 Scientists at Al-Ma'mun's observatory discovered that the solar apogee, the point at which the sun is farthest from the Earth, changes over time.

11 We now know the solar apogee changes because the whole solar system moves within our galaxy.

12 The Maragha Observatory, built in northern Persia (now Iran) in 1263, had a library with more than 40,000 books.

13 The astronomer Jamal al-Din introduced instruments from the observatory to China in 1267.

14 The foundations of the Maragha Observatory still stand in Iran.

15 The 15th-century astronomer-mathematician Ulugh Beg created an observatory in Samarkand (now in Uzbekistan) while he was Sultan.

16 Ulugh Beg calculated the length of a year at 365 days, 6 hours, 10 minutes, and 8 seconds—just 62 seconds longer than the figure used today!

17 In the 9th century 'Abbas ibn Firnas built a glass planetarium in his house that showed images of stars and planets.

18 HIS PLANETARIUM EVEN FEATURED ARTIFICIAL THUNDER AND LIGHTNING.

19 Many astronomical instruments created in the early Muslim world greatly influenced the development of modern astronomy.

20 These new kinds of astrolabes, sextants, and quadrants measured the height of stars more accurately than ever before.

21 SEXTANTS WERE THE GPS OF THE MEDIEVAL WORLD.

22 Astrolabes, sextants, and quadrants helped make possible the European age of exploration.

23 An amazing observatory built by Taqi al-Din in Istanbul, Turkey, had an impressive array of extremely large instruments.

24 Large instruments made more accurate measurements possible.

25 THE OBSERVATORY IN DAMASCUS, SYRIA, HAD A 20-FOOT (6-M) QUADRANT AND A 56-FOOT (17-M) SEXTANT.

26 Today some of the largest optical telescopes are in the Canary Islands.

27 The need to know prayer times and the direction of Mecca led to substantial improvements in the astrolabe, an ancient instrument.

28 An astrolabe shows how the 3-D sky would look if it were flat.

29 People used astrolabes to tell time day or night, navigate on land, and calculate sunrise and sunset.

30 Astrolabes are sometimes called the pocket watches of the medieval world.

31 Observations made with astrolabes helped lead to the birth of modern astronomy.

32 The astrolabe is considered the most important astronomical observational device before the invention of the telescope.

33 It could take up to six months to build an astrolabe because the makers had to do extensive calculations, engrave all the parts, and then assemble them all by hand.

34 THE OLDEST KNOWN ASTROLABE MADE IN THE MUSLIM WORLD IS FROM 10TH-CENTURY BAGHDAD.

35 Using a huge astrolabe, astronomer Ibn Yunus recorded more than 10,000 observations of the sun's position during a 30-year period.

36 The astrolabe was based on the ancient Greek model of the universe described by Ptolemy that showed the Earth at the center.

37 In 1387 Geoffrey Chaucer, author of *The Canterbury Tales*, gave his young son an astrolabe made to work for Oxford, England.

Ahmad al-Mizzi's quadrant; foreground: armillary sphere



75

OUT OF THIS
WORLD FACTS
ABOUT

38 The universal astrolabe, developed in Toledo, Spain, in the 11th century by Al-Zarqali, changed star mapping forever.

39 The universal astrolabe could be used at any location.

40 Jabir ibn Aflah, who lived in the 1100s, designed the first portable celestial globe to measure coordinates of planets and stars.

41 Since ancient times astronomers have used 3-D models of the heavens called armillary spheres.

42 These spheres have rings set at different angles to show the paths of planets and stars.

43 By the 10th century the Muslim world was producing two kinds of complex armillary spheres: demonstrational and observational.

44 DEMONSTRATIONAL ARMILLARY SPHERES PUT THE EARTH AT THE CENTER WITH THE SUN, TROPICS, EQUATOR, AND POLAR CIRCLES MOVING AROUND IT.

45 Observational armillary spheres had sighting devices on the rings but did not have the Earth at the center.

46 Using armillary spheres, astronomers produced flat charts of the heavens, which were then used to make astrolabes.

47 THE ALMAGEST, BY 2ND-CENTURY B.C.E. GREEK SCHOLAR PTOLEMY, HAD AN IMPORTANT INFLUENCE ON ASTRONOMERS OF THE MUSLIM WORLD.

48 Ninth-century astronomer Al-Farghani, inspired by Ptolemy's work, wrote several important books on astronomy.

49 The medieval Italian poet Dante probably gained his astronomical knowledge by studying the writings of Al-Farghani in Latin.

50 One of Al-Farghani's most important inventions was the Nilometer. Created in 861, it measured the water level of the Nile at Cairo and predicted when the river would flood each year.

51 Scientist Al-Battani combined elements of the celestial globe and the armillary sphere to create a new instrument called *al-baydha*, meaning "the egg."

52 The creation of the egg allowed astronomers to assign stars exact coordinates.

53 Al-Battani is also credited with timing new moons, calculating the length of solar years, and predicting eclipses.

54 Star maps created in the Muslim world were used in Europe and the Far East for centuries.

55 Today the names of more than 165 stars reflect their Arabic origins.

56 THE ASTRONOMER 'ABD AL-RAHMAN AL-SUFI WAS THE FIRST TO MENTION A STAR SYSTEM BEYOND OUR MILKY WAY GALAXY.

57 In 964 Al-Sufi named his find "little cloud." Today we call it the Andromeda galaxy.

58 The Andromeda galaxy is about 2.6 million light-years from Earth.

59 Our Milky Way galaxy contains between 200 and 400 billion stars.

60 The Milky Way is about 1,000 light-years thick, 100,000 light-years wide, and 300,000 light-years around.

61 The terms "zenith" and "azimuth" are of Arabic origin.

62 The astronomer Qutb al-Din al-Shirazi and his student Kamal al-Din al-Farisi explained that rainbows are caused by the refraction of the sun's rays in raindrops.

63 According to Copernicus, Ibn Rushd, a philosopher and astronomer, may have observed sunspots.

64 The 17th-century astronomer Galileo Galilei built on Latin translations of works written by astronomers of the Muslim world.

65 Six hundred years before Galileo, Muslim astronomer Al-Biruni explored the idea that the Earth rotated on its own axis.

66 Al-Biruni is sometimes referred to as the Leonardo da Vinci of his day.

67 Astronomer-scientist Thabit ibn Qurra lived in Baghdad, where he revised many Arabic versions of ancient Greek and Syriac science texts before his death in 901.

68 IT WAS EASIER FOR EARLY CIVILIZATIONS TO OBSERVE PLANETS AND STARS WITH THE NAKED EYE BECAUSE THERE WERE NO BRIGHT CITY LIGHTS.

69 Human eyes can take up to an hour to adjust to the night sky. This "night vision" makes it easier to see things that are farther away and less bright in the sky.

70 There are five planets that can be easily seen with the naked eye: Mercury, Venus, Jupiter, Mars, and Saturn.

71 Unlike some earlier thinkers, the scholars of Muslim civilization did not believe that the stars and planets were living beings.

72 The Quran talks about orbits and other astronomical phenomena.

73 The groundbreaking observations and discoveries made by astronomers during Muslim civilization had a huge impact on astronomy in the Western world.

74 Among those influenced by these medieval astronomers was Nicolaus Copernicus, a Renaissance scholar from Poland who is often considered the founder of modern astronomy.

75 Copernicus relied heavily on work done by Al-Battani, Ibn al-Shatir, Nasir al-Din al-Tusi, and other astronomers of the Muslim world.

ASTRONOMY

15

LUNAR FACTS ABOUT

1 In Muslim civilization **astronomers** were fascinated by the phases of the Moon.

2 Astronomers in early Muslim civilization **calculated precisely** when the **crescent moon** would appear—important information for followers of Islam.

3 The crescent moon marks the beginning of **Ramadan** and other months in the Islamic calendar.



4 Al-Kindi, a 9th-century Iraqi, developed a type of **trigonometry** that dealt with **spheres** rather than flat surfaces.

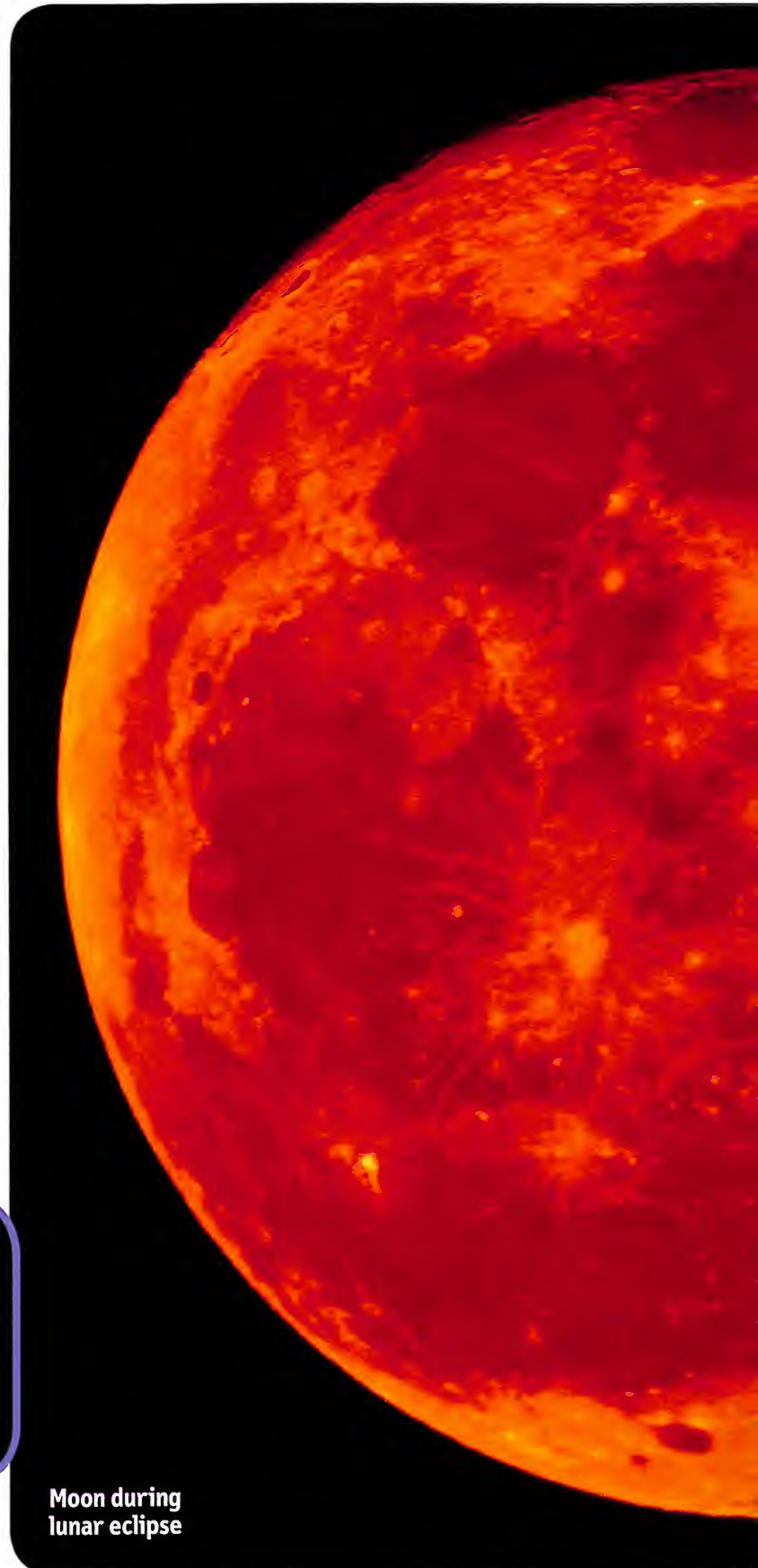


5 People needed **spherical trigonometry** to find the direction of Mecca, the holiest place of Islam, from any point on Earth.

6 Astronomer Muhammad Abu al-Wafa' al-Buzjani discovered that the **moon** travels at **different speeds** during different phases.



7 The Danish astronomer Tycho Brahe is often credited with discovering this **lunar phenomenon**, but his discovery came **600 years after** Al-Buzjani's.



Moon during lunar eclipse

THE MOON



8 A crater on the moon is named after Abu al-Wafa' al-Buzjani.



9 The Islamic calendar has 12 months that begin and end according to the lunar cycle.



10 In 634 the second ruler of the Muslim world introduced the hijri date system, a calendar based on the lunar cycle, which is still in use today.

11 The hijri, or Islamic calendar, is only 354 or 355 days long, 11 days shorter than calendars based on the Earth's revolution around the sun.



12 Ibn al-Haytham studied the moon at different positions in the sky and discovered that its larger appearance near the horizon is an optical illusion. The moon's real size never changes.

13 The moon's surface has more than 650 dark and light patches, caused by craters and other formations. Thirteen of these are named for Muslim astronomers.

14 Lunar formations are part of what creates the "man in the moon" phenomenon we can see from the Earth.

15 The moon has been known by many names: "Luna" by the Romans, "Selene" by the Greeks, and Al-Qamar by Arabs.



1 Humans have been **fascinated** by the stars since the beginning of time.

The world's oldest star map—**carved into a mammoth's tusk**—is believed to be about **35,000 YEARS OLD!**

4 Ninth-century scholars at the **HOUSE OF WISDOM** in Baghdad translated and studied texts about astronomy from **GREEK, ROMAN,** and other early civilizations.

2 The wonder of the **STARRY SKIES** impressed the scholars of Muslim civilization. In line with earlier thinkers, they looked for **ORDER AND LOGIC** in what they saw.



3 Today we still know many constellations by names from **ANCIENT GREEK** legends, including **HERCULES the HERO** and **PEGASUS the WINGED HORSE.**

5 **MUSLIM ASTRONOMERS BUILT OBSERVATORIES TO STUDY THE STARS, MOON, AND PLANETS.** THESE OBSERVATORIES WERE THE HIGH-TECH LABORATORIES OF THEIR DAY.

25

Stellar FACTS ABOUT

6 The **FIRST WRITTEN RECORD** of a star system outside our own galaxy came from **ABD AL-RAHMAN AL-SUFI** in **964.**

7 **Al-Sufi's BOOK OF FIXED STARS,** an update to Greek astronomer Ptolemy's star catalog, became the standard constellation handbook for **SEVERAL CENTURIES.**



8 "FIXED STARS" referred to **CELESTIAL OBJECTS** THAT DID NOT SEEM TO MOVE IN RELATION TO OTHER STARS.

9 **TODAY WE KNOW THAT STARS IN CONSTELLATIONS DO CHANGE POSITION—THEY'RE JUST SO FAR AWAY, WE CAN'T SEE THEM MOVE.**

10 Al-Sufi's book identified and illustrated **48 CONSTELLATIONS.**

11 Astronomers in the Muslim world made better and better **CELESTIAL GLOBES** to mark the positions of the stars and constellations in the sky.

12 **AL-SUFI** gave the **POSITION, SIZE, and COLOR** of each constellation.

13 Stars can be **RED, BLUE, or YELLOW.**

14 Cold stars are **RED;** hot stars are **BLUE.**



15

STAR MAPS AND ASTRONOMICAL TABLES from the Muslim world were used in Europe and the Far East for centuries.



16

ANCIENT GREEK STARGAZERS named many constellations after mythical figures, like **ORION THE HUNTER**.

18

To astronomers of the Muslim world **CASSIOPEIA** resembled a hand stained with henna.



17

FIVE MAIN STARS FORM THE W-SHAPED CONSTELLATION CASSIOPEIA. SEVERAL OF ITS STAR NAMES HAVE ARABIC ROOTS, INCLUDING SCHEDAR, FROM SADR, MEANING "BREAST" IN ARABIC, AND CAPH, FROM KAFF, MEANING "STAINED HAND."



CONSTELLATIONS

19

ORION, one of the **MOST RECOGNIZABLE** constellations, is joined by his hunting dogs, **CANIS MAJOR** and **CANIS MINOR**.



20

ASTRONOMERS of Muslim civilization added **ARABIC NAMES** and their own sightings of **STARS**.

21

Muslim astronomers recorded and named more than **1,000 STARS**.



22

ONE HUNDRED AND SIXTY STARS are known worldwide by their Arabic names, including Aldebaran ("Follower" of the Pleiades) and Altair ("The Flying Eagle").

24

The "modern family" of **CONSTELLATIONS** includes 19 land animals, 13 humans, 10 water creatures, 9 birds, 2 centaurs, a dragon, a unicorn, **AND A HEAD OF HAIR!**

25



You can still see parts of a star map on the dome of a bathhouse in an 8th-century palace in a desert in Jordan.

TODAY 88 CONSTELLATIONS ARE RECOGNIZED BY THE INTERNATIONAL ASTRONOMICAL UNION.

23

15

SOARING FACTS



1 Since the beginning of time every civilization has seen **birds flying** and **dreamed of taking flight** themselves.

2 The Muslim civilization's **fascination with flight** was reinforced by the belief that when the human soul reaches the highest level of goodness it **risers above the Earth**.

3 In his *Book of Kings*, Persian poet Al-Firdawsi recounted the tale of King Kai Kawus, who was tempted by evil spirits to invade heaven on a flying throne. **The eagles carrying him grew tired, and he crashed.**



4 In 852 a Spanish Muslim named 'Abbas ibn Firnas made an early **parachute jump** when he **leaped** off the Great Mosque of Córdoba (Spain) **wearing a reinforced cloak**.

5 Twenty-three years later, 65-year-old Ibn Firnas made the first controlled flight using what we would call a **hang glider**.

6 Ibn Firnas's hang glider resembled **a bird costume made of silk and covered with eagle feathers**.



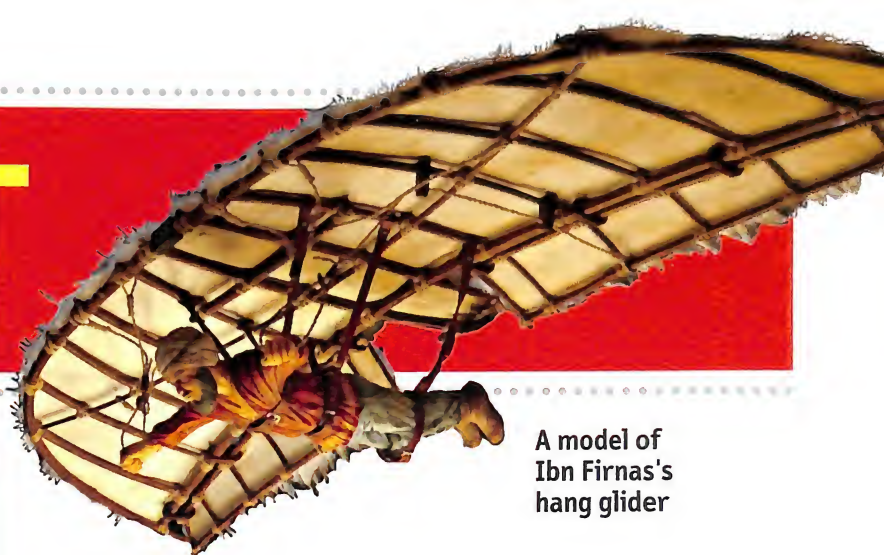
7 The story goes that Ibn Firnas **hung in the air for more than ten minutes** using his glider before crashing to the ground.

8 The **rough landing** made the flight pioneer realize the important role a bird's tail plays in a safe landing. **Today all planes touch down with rear wheels first.**



Chinese red dragon kite

ON FLIGHT



A model of
Ibn Firnas's
hang glider

- 9 Leonardo da Vinci made his **famous drawings of birdlike flying machines** almost seven centuries after 'Abbas ibn Firnas's experiments with flight.



- 10 In the 17th century, a Turk named Hazarfen Ahmed Celebi **used an eagle-feathered glider** to fly across **the Bosphorus**, a strait that flows through **Istanbul, Turkey**.

- 11 In 1971 a Turkish **postage stamp** was created to honor Hazarfen Ahmed Celebi's **famous flight**.

- 12 **Great snipes** hold the record for the fastest long-distance, nonstop flight of **any living bird**.



- 13 The **first manned rocket** was said to have been invented by Lagari Hasan Celebi in 1633.

- 14 Lagari Hasan Celebi's **gunpowder-fueled rocket** carried him **high into the sky**, where he spread out wings and glided down before plunging into the water. For his risky flight Celebi was **rewarded with a pouch of gold** from the Sultan.

- 15 **Birds also influenced the thinking of the Wright brothers**, whose successful flight in 1903 paved the way for **modern aviation**.



1
A THOUSAND YEARS AGO,
BAGHDAD
BOASTED THE TOP
INTELLECTUAL ESTABLISHMENT
OF THE DAY: THE *BAYT AL-HIKMA*, OR
HOUSE OF WISDOM.

2
Drawing on Persian, Indian,
and Greek texts, the
HOUSE OF WISDOM SCHOLARS
accumulated one of the greatest
COLLECTIONS OF KNOWLEDGE
in the known world, then built on
it through their own discoveries.

3
**THIS LEARNING CENTER WAS
THE 9TH-CENTURY BRAIN-
CHILD OF FOUR GENERATIONS
OF RULERS, OR CALIPHS, WHO
BOUGHT THE TOP SCHOLARS
FROM ALL OVER THE MUSLIM
WORLD UNDER ONE ROOF.**

4
**RESEARCH AND
DISCOVERIES
AT THE HOUSE OF WISDOM
PROVIDED A FOUNDATION
FOR MUCH OF WHAT WE
KNOW TODAY.**



5
The House of Wisdom
featured a massive
library, with books on
every subject
written in
many languages.



25 BRAINY

6
This intellectual powerhouse
turned **BAGHDAD** into the
headquarters for the arts,
sciences, and writing and played
a major part in the spread and
development of **KNOWLEDGE** in
these fields.


7
**THE HOUSE
OF WISDOM
WAS OPEN TO
TO MEN AND WOMEN
OF ALL FAITHS.**

8
CALIPH AL-MA'MUN USED
CAMELS
TO CARRY HUNDREDS OF
BOOKS AND MANUSCRIPTS
FROM OTHER PARTS OF THE MUSLIM
WORLD TO THE HOUSE OF WISDOM.



9
THE LIBRARY **GREW**
SO LARGE THAT AL-MA'MUN
BUILT EXTENSIONS TO HOUSE
DIFFERENT BRANCHES OF
KNOWLEDGE.

10
SO MANY
SCHOLARS
WANTED TO COME THAT
AL-MA'MUN KEPT HAVING TO
EXPAND THE STUDY CENTERS.

11

**CALIPH
AL-MA'MUN IS SAID TO HAVE**
encouraged translators and scholars to
add to the House of Wisdom library by
paying them the weight of each
COMPLETED BOOK IN GOLD.

12
AL-MA'MUN BUILT AN ASTRONOMY CENTER IN
BAGHDAD AND SET UP DOZENS OF LEARNING
CENTERS ALL OVER THE MUSLIM WORLD.



13
SCHOLARS
MET EACH DAY FOR
READING, WRITING,
AND DISCUSSION,
USING SEVERAL
LANGUAGES,
INCLUDING ARABIC,
PERSIAN, GREEK,
AND SYRIAC.

14
**EXPERTS
WORKED TO
TRANSLATE
WRITINGS FROM
OTHER CIVILIZATIONS
INTO ARABIC SO
SCHOLARS COULD
READ, DEBATE, AND
BUILD ON THEM.**

15

The legacy of Al-Ma'mun lives on through a lunar crater named **"ALMANON"**—a deserved tribute to a ruler who was a great lover of knowledge.

16

OTHER CITIES IN THE ISLAMIC WORLD FOLLOWED BAGHDAD'S LEAD AND ESTABLISHED THEIR OWN VERSIONS OF THE HOUSE OF WISDOM IN THE 9TH AND 10TH CENTURIES.



17

THE WORD "ALGEBRA" COMES FROM THE TITLE OF THE BOOK *AL-JABR WA-L-MUQABALAH*, BY AL-KHWARIZMI, A SCHOLAR AT THE HOUSE OF WISDOM DURING THE EARLY 9TH CENTURY.

18

The three Banu Musa brothers, mathematicians and inventors of machines and trick devices, Al-Khwarizmi, the "father of algebra," and Al-Kindi, philosopher, mathematician, and inventor of decryption, are among the House of Wisdom's most famous **SCHOLARS.**



FACTS ABOUT THE HOUSE OF WISDOM

19

SOME LIBRARIES WERE SUPER-LAVISH: TOPPED WITH DOMES, WITH NUMEROUS ROOMS FILLED WITH BOOKS AND SURROUNDED BY GARDENS WITH LAKES.



20

AT ONE POINT BAGHDAD HAD

36 LIBRARIES
AND MORE THAN A
HUNDRED
BOOK DEALERS.

21

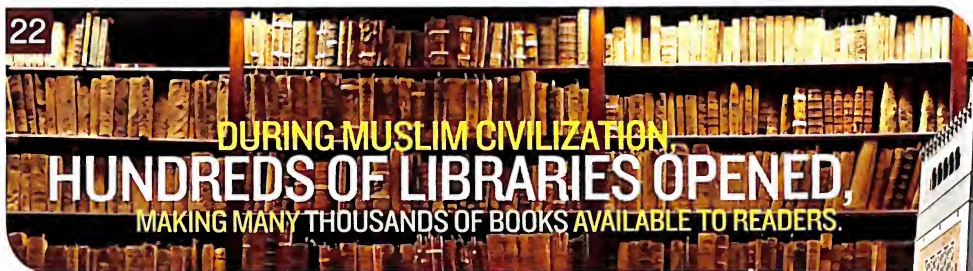


DURING THE 12TH CENTURY

ONE STREET
IN MARRAKECH, MOROCCO, HAD
100 BOOKSHOPS
AND LIBRARIES,
50 ON EACH SIDE!

22

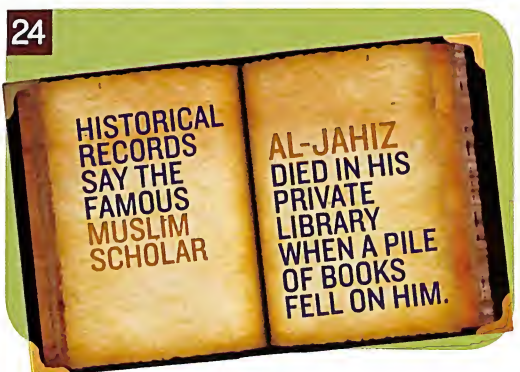
DURING MUSLIM CIVILIZATION,
HUNDREDS OF LIBRARIES OPENED,
MAKING MANY THOUSANDS OF BOOKS AVAILABLE TO READERS.



24

HISTORICAL RECORDS SAY THE FAMOUS MUSLIM SCHOLAR

AL-JAHIZ DIED IN HIS PRIVATE LIBRARY WHEN A PILE OF BOOKS FELL ON HIM.



25

THE LIBRARY OF THE ZAYTUNA MOSQUE IN TUNISIA HAD MORE THAN

100,000 BOOKS.

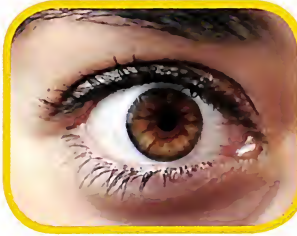


23

MANY MUSLIM TOWNS ALSO HAD BOOKSHOPS, WHERE PEOPLE WOULD COME TO BUY BOOKS, EAT AND DRINK, AND SHARE IDEAS.

15

EYE-POPPING



1 Much of what we know about the **eye and vision** was influenced by scientists in Muslim civilization, beginning in the **9th century**.

2 The scholars of Islam inherited **two theories about vision** from the Greeks. One said we see because our eyes send out invisible, laser-like rays that make objects visible. The other said we see because something representing an object **enters our eyes**.

3 Figuring out how the eye works is one of the most outstanding **scientific legacies** of Muslim civilization.



4 Ninth-century philosopher and scientist **Al-Kindi** was the first to lay down the foundations of **modern-day optics** by questioning earlier theories of vision.

5 Al-Kindi has been called “one of the **12 giant minds** of history.”

6 One century later **Ibn al-Haytham**, a mathematician, astronomer, and physicist, used experiments to build on Al-Kindi’s work and provide a more detailed theory of **vision**.

7 Al-Kindi’s **meticulous experiments** helped Ibn al-Haytham prove that we see because of **light rays** coming from the objects, not from the eye.

8 **Scientific theories** were often accepted without proof. Ibn al-Haytham was among the first to use experiments to check theories. His *Book of Optics* is still a **brilliant example** of writing on the scientific method.



View through a camera lens with an open shutter



VISION FACTS



9 Leonardo da Vinci may have learned from Ibn al-Haytham's book after it was translated from Arabic into **Latin**.

10 Ibn al-Haytham experimented with the **pinhole camera** while under house arrest in Cairo, Egypt.



11 One day Ibn al-Haytham noticed that light coming through a **tiny hole** in the shutters projected an image of the **outside world** onto the opposite wall of his dark room.

12 After **discovering** that the smaller the hole, the more focused the light and the sharper the image, Ibn al-Haytham confirmed light travels in a straight line. This led to the **camera obscura**, a forerunner to the modern camera.

13 The camera obscura had a large, **dark chamber** the size of a small room with a pinhole opening for light to shine through. The image projected by the light was traced onto a drawing surface to **produce a picture**.



14 The **earliest** known surviving photograph was shot in **France** in 1827, using a camera obscura.

15 "**Camera obscura**" is the Latin translation of "**dark room**," as originally used by Ibn al-Haytham, which in modern Arabic is **qamara**.



1 A THOUSAND YEARS BEFORE EUROPEANS MADE SIGNIFICANT ADVANCES IN THE FIELD, SCHOLARS IN MUSLIM CIVILIZATION WERE **CREATING NEW MATHEMATICAL KNOWLEDGE** AND BROADENING THE SCOPE OF **MATH.**

4 **AL-KHWARIZMI** IS KNOWN IN LATIN AS **ALGORITMI**, THE SOURCE OF THE MATH AND COMPUTER TERM "ALGORITHM."

2 NEXT TIME YOU DO YOUR **ALGEBRA HOMEWORK**, YOU HAVE MUSLIM MATHEMATICIAN **AL-KHWARIZMI** TO THANK. THE "FATHER OF ALGEBRA" INTRODUCED NEW CONCEPTS IN MATH IN BAGHDAD AROUND 830.

3 MATHEMATICAL INVENTIONS FROM MUSLIM CIVILIZATION INCLUDE **THE CREATION OF ALGEBRA**, ADDITIONS TO GEOMETRY, THE DECIMAL NUMBERING SYSTEM, THE SINE AND COSINE, AND MANY OTHERS OF **LASTING INFLUENCE.**

5 ALGEBRA REVOLUTIONIZED THE WAY PEOPLE LOOKED AT **NUMBERS** AND BROKE AWAY FROM GEOMETRY, WHICH WAS THE ROOT OF THE GREEK CONCEPT OF MATH.

25

NIFTY

6 AL-KHWARIZMI'S book, *Al-Jabr wa-l-Muqabala*, introduced the basics of the algebra we study today.



7 **AL-KARAJI**, another mathematician, **BUILT ON THE RULES OF ALGEBRA** and started an algebra school that **THRIVED FOR SEVERAL** hundred years.

9 MUSLIMS WERE THE FIRST TO GIVE **ZERO** A MATHEMATICAL PROPERTY. Without this contribution, there would be no way to tell the difference between numbers like **23** and **203**.

10 **EVEN POETS LOVED MATH** IN MUSLIM CIVILIZATION. THE POET WE KNOW TODAY AS **UMAR AL-KHAYYAM** CONTRIBUTED TO ALGEBRA WITH HIS IDEAS ABOUT SOLVING COMPLEX EQUATIONS.

8 **GEOMETRY** WAS USED IN MANY DESIGNS IN THE MUSLIM WORLD, LIKE THE DAZZLING TILE MOSAICS ON MOSQUES AND PALACES. **THE MATHEMATICAL SIGNIFICANCE OF MUSLIM TILES AND DESIGNS WAS DISCOVERED ONLY RECENTLY.**

11 **ALGEBRA** MADE ITS WAY TO EUROPE BY THE **12TH CENTURY.**

12 THE NUMBERS WE USE TODAY (**0, 1, 2, ... 9**) COME FROM THE ARABIC SYMBOLS USED MORE THAN **1,000 YEARS AGO.**

13 MUSLIMS HAD TWO COUNTING, OR NUMERICAL, SYSTEMS: **ONE** in which numbers were written as letters of the alphabet; **AND ANOTHER** in which numbers were written using ancient Babylonian symbols.

14 THE TWO TRADITIONAL MUSLIM COUNTING SYSTEMS WERE EVENTUALLY REPLACED BY NEW NUMBERS KNOWN AS **ARABIC NUMERALS**, DEVELOPED FROM AN ANCIENT INDIAN SYSTEM.

15

ARABIC NUMERALS
WERE ALSO KNOWN AS
**GHUBARI
NUMBERS**
BECAUSE MUSLIMS INITIALLY
USED DUST (GHUBAR)
BOARDS TO MAKE
CALCULATIONS.

16

ARABIC NUMERALS MADE CALCULATIONS MUCH EASIER THAN
THE ROMAN SYSTEM, WHICH USED LETTERS LIKE

X, V, I, L, C, AND M

FOR NUMBERS, OR OTHER SYSTEMS BASED ON
DOTS, PICTOGRAPHS, OR FINGER COUNTING.

17

Arabic numerals also led
to the introduction of

**SIMPLE
FRACTIONS**

and decimal fractions
(a fraction in which the
bottom number is a
power of ten).



18

BEGINNING IN THE
11TH CENTURY,
STUDENTS

STUDYING IN
MUSLIM LEARNING
CENTERS IN NORTH AFRICA
AND SOUTHERN EUROPE
INTRODUCED ARABIC
NUMERALS TO THE REST
OF **EUROPE**.



NUMBER FACTS

19

Al-Biruni, one of the greatest
Muslim scholars, used

TRIGONOMETRY

to come up with a figure

for the **EARTH'S
CIRCUMFERENCE**

that is very close to the
accepted value today.



20

IN THE EARLY
9TH CENTURY
AL-KHWARIZMI CONSTRUCTED
TABLES THAT COULD HELP
CALCULATE MISSING VALUES IN
ASTRONOMICAL TABLES
THAT DEFINE THE LOCATIONS OF

STARS.

21

TODAY TRIGONOMETRY
IS USED TO
CALCULATE DISTANCES
TO THE STARS, MEASURE THE
HEIGHTS OF BUILDINGS AND TREES,
AND MUCH MORE.



22

THE SCHOLARS AT THE **HOUSE OF WISDOM** IN BAGHDAD AND AT
UNIVERSITIES IN CAIRO, EGYPT, PICKED UP WHERE THE GREEKS
LEFT OFF, THEN ADDED THEIR OWN CONTRIBUTIONS TO

GEOMETRY.



24

IN THE 10TH CENTURY, IBN AL-HAYTHAM
WAS THE FIRST MATHEMATICIAN TO
FIGURE OUT HOW TO FIND ALL

EVEN PERFECT NUMBERS—
A SET OF UNIQUE NUMBERS THAT HAS
FASCINATED THINKERS SINCE
ANCIENT TIMES.

25



COMPLEX **GEOMETRIC PATTERNS** WERE USED IN MUSLIM
ARCHITECTURE TO COVER WALLS, CEILINGS, FLOORS, AND ARCHES.

WITH A BETTER UNDERSTANDING FOR MATH, PEOPLE WERE ABLE
TO USE IT AS A PRACTICAL TOOL IN BUSINESS AND EVERYDAY LIFE.

23



15

TIMELY FACTS



1 Seven hundred years ago, people in Muslim civilization designed clever clocks that were powered by **water**.

2 Ancient Egyptians introduced **water clocks**, also known as *clepsydras*, around 1500 B.C.E. that measured time by the flow of water in a small bowl. They could be used 24/7 in any weather.



3 One of the **oldest** water clocks was found in the tomb of the Egyptian pharaoh **Amenhotep I**, who died around 1500 B.C.E.

4 Water clocks were used in ancient **Greece** to time the length of speeches. Scholars in the Muslim world improved upon early Greek and Indian clocks and **pioneered** many ideas in mechanical design.

5 In Greek *clepsydra* means "**water thief**."

6 The study of **timekeeping** is known as horology.

7 Timekeeping was very **important** to Muslims, who had to know when to perform each of the **five daily prayers**.

8 Clocks also helped keep track of important **religious** events, such as when to begin and end the daily fast during Ramadan when it was hard to see the dawn or sunset.



Modern clock mechanisms

ABOUT CLOCKS



9 In the 13th century **Al-Jazari**, a brilliant mechanical engineer, wrote a book detailing how to **build** dozens of **machines**, including clocks of different types, shapes, and sizes.



10 Al-Jazari's **influential book** also included an automatic hand-washing machine and a robotic **musical band**.



11 One of Al-Jazari's most **famous** creations was the **Elephant Clock**, which was powered by water and weights and featured moving robotic figures that told the time.

12 The Elephant Clock had **Chinese dragons**, an Egyptian phoenix, and wooden robots in Arabian clothing, reflecting cultures from across the world.

13 Every half hour the Elephant Clock's timer set off a series of **dramatic** sights and sounds, ending with the clash of a **cymbal**.

14 Inside the Elephant Clock was a **hidden water tank** with a slowly sinking bowl that controlled the timing.

15 Water and mechanical clocks were the standard way to **tell time** all over the world until Dutch scientist Christiaan Huygens introduced the **pendulum clock** in 1656.



15

PUZZLING FACTS

1 In 9th-century Baghdad three mathematicians—the **Banu Musa brothers**—invented ingenious trick devices and puzzles that were like the **Rubik's Cube** of their time.

2 More than **300 million** Rubik's Cubes have been sold worldwide. Stacked end to end, they would **stretch** from the North Pole to the South Pole!



3 The **record** for solving a Rubik's Cube is **6.24 seconds**.

4 The Banu Musa brothers built upon Greek knowledge and helped kick-start the development of **mechanical technology**.



5 **Al-Biruni**, another scholar in the medieval Muslim world, wrote about **number puzzles**.

6 It took a few centuries for **Europe** to catch up with the innovative thinkers of Muslim civilization.

7 Like the Banu Musa brothers, many of the Muslim scholars studied at the **House of Wisdom**, a famous scientific academy in Baghdad founded in the 9th century.

8 Published around 850, the Banu Musa brothers' *Book of Ingenious Devices* illustrated more than **100 trick gadgets and machines**.



Sudoku, a modern version of a mind game

ABOUT GAMES



9 Some of the brothers' **funnier** trick devices involved fake animals and sounds and relied on water and air pressure, siphons, **valves**, and floats to make them work.

10 The brothers are credited with developing the earliest **robotic devices**, including birds that could sing and flap their wings.



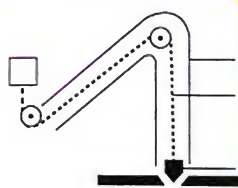
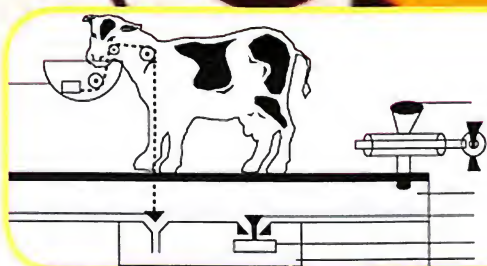
11 The Banu Musa brothers also are credited with creating the on-off switch and **the gas mask**.

12 The brothers' "**magic flask**" had two spouts that could be filled with different-color liquids. The liquids would mysteriously swap places inside the flask so the "wrong" color would come out of each spout.

13 The brothers' automatic **flute player**, which used steam to produce flute sounds, may be the world's first programmable machine—not that different from a **computer** you might program today.



14 These devices provided hours of **entertainment** and showed an incredible level of skill and craftsmanship.



15 The "**Drinking Bull**" featured a robotic bull that gave a contented sigh after drinking water.

15

MUSIC FACTS



1 Medieval Muslim musicians played the **qitara**, an early version of the guitar.

2 The musical scale has its roots in early Muslim civilization. Do, re, mi, fa, sol, la, ti sound close to the names of some letters of the Arabic alphabet, such as *dal*, *ra*, *mim*, and *fa*.

3 Roving musicians, merchants, and travelers helped spread Arabic **music** to Europe.



4 A handsome singer called **Ziryab** was a very popular musician in 9th-century Muslim Spain.



5 **Al-Farabi**, a 10th-century philosopher and musician, developed the *rababah* (an early type of violin) and the **qanun** (similar to a table zither). He wrote *The Great Book of Music*, which was first translated into Hebrew, then Latin.

6 As **entertainer** to the court of the Umayyad Caliph in Córdoba, Ziryab was paid a monthly salary of **200 golden dinars**.

7 Today the **guitar** is considered the most popular instrument in the world.





TO TAKE NOTE OF



8 Musicians are shown **playing** Arabic instruments in artwork from Spain that dates back nearly 800 years.

9 Ziryab established the world's first **music school** and brought the **Arab lute**, a plucked string instrument, to Europe.

10 Ziryab plucked the strings of his **lute** with a **vulture's feather**.

11 The lute became the most important instrument for **popular** music in Europe from the **14th to 17th centuries**.



12 The word **tar**, in *qitara*, means "**string**" in **Persian**.

13 The world's earliest **military band** was probably formed in 14th-century Turkey. Its purpose? To **motivate** the soldiers and **scare** the enemy during battle.



14 It's said that European military bands started after **Turkish troops** abandoned their instruments after their defeat in Vienna, Austria, in **1683**.

15 **Napoleon Bonaparte's** military band had kettledrums, cymbals, and other Turkish instruments. Its **noisy fanfare** helped win the Battle of Austerlitz in 1805.



Close-up of the soundhole of a lute

1

Pharmacies, hospitals, and medical schools were **common** in the early Muslim world.

2

Unlike healing centers in ancient Greece, the **pioneering** health-care system in Muslim civilization focused on diagnosis and treatment rather than on **miraculous cures**.

3

Hospital patients in the early Muslim world might take **syrups**, pills, and powders; undergo surgery; or have a **cast** put on a broken leg.

4

Muslim rulers competed with each other to create the best hospitals that were **open to all**.

5

The **first** major **hospital** was **built** in Cairo, Egypt, between 872 and 874. It was named for Ahmad ibn Tulun, a Muslim ruler in Egypt.

6

Unlike in the Western world today, **herbal medicine** in the 10th-century Muslim world was not seen as alternative medicine.

7

A thousand years ago in the Muslim world medical care was **free** for everyone and included very advanced treatments—even **music therapy**.

8

Because Muslims are **honor-bound** by the Quran to care for the sick, early hospitals treated people of **all faiths**, rich or poor, man or woman.

9

The earliest hospitals in Muslim civilization began in **Baghdad** in the 8th century.

10

Patients with **leprosy** could get treatment at Al-Qayrawan hospital in 9th-century Tunisia, even though many people thought the disease was a **sign of evil**.

11

Al-Nuri Hospital in Damascus, Syria, had inspectors who made sure the care met the **highest standards**.

12

Damascus's highly advanced hospital was one of the **first teaching hospitals** in the world.

13

Doctors in Muslim civilization were required to have **rigorous medical training** in a teaching hospital, much like doctors are today.

14

Muslim hospitals were built in southern Spain and other areas of Europe that were part of **Muslim civilization**.

15

Muslim hospitals were funded by **charitable gifts** called **awqaf**.

16

Muslim scientist Sinan ibn Thabit ibn Qurra started **mobile** hospital services for rural areas.

17

In the 13th century Ibn al-Nafis accurately described how in the **lungs**, blood coming from the heart **mixes with the air**.

18

Ibn al-Nafis was **not credited** with this great discovery until **1957!**

19

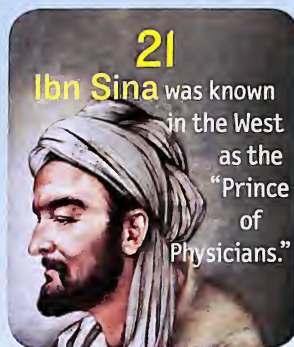
In the 17th century an English doctor named William Harvey discovered the complete blood **circulatory** system.

20

Eleventh-century doctor and philosopher Ibn Sina developed a method for treating **fractured bones** that is still used today.

21

Ibn Sina was known in the West as the "Prince of Physicians."



22

Ibn Sina wrote a highly **influential** medical textbook: the **Code of Laws in Medicine**, or the **Canon**.

23

The **Canon** was printed in Rome in 1593 and went on to become a **standard text** in European medical schools.

24



The **Canon** influenced the layout of modern medical textbooks, such as **Gray's Anatomy**, first published in 1858 and now the leading Western medical encyclopedia.

25

Medical books written in the 11th-century Muslim world were **translated** from Arabic into Latin to help spread the knowledge in Europe.

26

The first book solely on **pediatrics**, or children's medicine, was written by Tunisian-born Ibn al-Jazzar al-Qayrawani back in the 9th century.

27

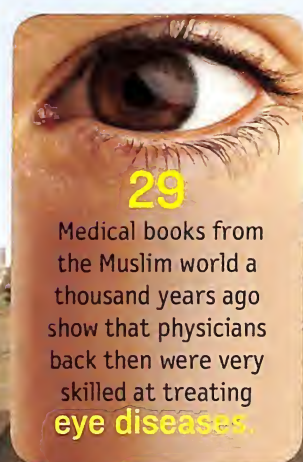
The first known alphabetical classification of medical terms was called **Kitab al-Ma'a**, or **The Book of Water**. The odd title comes from the fact that **Al-Ma'a**, which means "the water," is the first entry.

28

The Book of Water was rediscovered by the modern world, and in 1996 it was published by the government of Oman.

29

Medical books from the Muslim world a thousand years ago show that physicians back then were very skilled at treating **eye diseases**.



30

The **Notebook of the Oculist**, written in the 10th century, describes **130 eye diseases**.

31

As early as the year 1000, physicians in the Muslim world were working to find ways to **prevent blindness**.

32

Of the 30 ophthalmology textbooks written during early Muslim civilization, **14 still exist**.



33

Al-Kindi, a 9th-century scholar, was the first doctor to systematically determine **the dosage** for some drugs.

36

Edward Jenner is credited as the pioneer of **vaccination**. Unlike inoculation, Jenner used cowpox rather than smallpox itself to provide protection.

39

Pharmacies existed in Iraq more than **a thousand years ago**.

42

In 1967 the Turkish Postal Authority issued a stamp commemorating the **250th anniversary** of the first smallpox vaccination.



45

Ibn Sina's *Canon* had 142 **herbal remedies** made from plants, trees, seeds, and spices.



46

Al-Zahrawi had his patients swallow drugs in parcels made of **catgut**—the forerunner to present-day capsules.

47

Thanks to translations from Arabic to Latin by **Constantine the African**, a Tunisian scholar, medicine from the Muslim world found its way to Europe.

48

The largest encyclopedia of **drug usage** still in existence—*Dictionary of Simple Remedies and Food*—was written by the Spanish Muslim Ibn al-Baytar in the **13th century**.

49

Ibn al-Baytar had a system of **classifying plants** centuries before Swedish scientist Carl Linnaeus set up his.

50

Ahmad ibn Tulun Hospital in Egypt was the first to include a **mental health** department.

50

Healing
Facts About

MEDICINE

Al-Qayrawan hospital in Tunisia

34

Tribes in the Middle East and Africa were among the ancient peoples who knew of a life-saving process called **inoculation**.

35

In inoculation, or immunization, patients are given a controlled dose of a **disease-causing organism** so that their immune system learns to fight off the disease.

37

The word "vaccination" is derived from the Latin word **vacca**, meaning "cow."



38

In 1796 Jenner infected a young boy with cowpox, believing that it would immunize him against the **smallpox** virus. Lucky for all, the process worked.

40

Smallpox was one of the **deadliest diseases** in the world until 1980, when it was wiped out as the result of a worldwide vaccination campaign.



41

It is estimated that more than **300 million** deaths worldwide in the 20th century can be attributed to smallpox.

43

In 1721 Lady Mary Montagu, wife of the English ambassador to **Istanbul**, brought the idea of inoculation to England from Turkey, where it was well-known.



44

Spanish doctor Al-Zahrawi wrote the first **illustrated** book on medicine and surgery.


1 If you lived **a thousand years ago** in Muslim Spain, two types of surgery could have been performed on you:
GENERAL AND ORTHOPEDIC (BONES).

2 Al-Zahrawi, a 10th-century **SPANISH MUSLIM SURGEON**, is considered the **"father of modern surgery."**

3 IF YOU EVER NEED SURGERY, YOU CAN THANK AL-ZAHRAWI FOR CREATING MANY OF THE **medical instruments** used, including a **scalpel for cutting.**



4 **DON'T GET SCARED!** Al-Zahrawi was so concerned about his patients that **he invented A KNIFE with a HIDDEN BLADE.**

5  ALTHOUGH SURGERY WAS STILL DANGEROUS AND PAINFUL, AL-ZAHRAWI'S TOOLS WOULD HAVE HELPED TREAT PATIENTS SUFFERING FROM BONE DISEASES, TUMORS, AND WOUNDS AS WELL AS ASSISTING IN CHILDBIRTH.

25

FACTS ABOUT SURGERY YOU

6 Another tool Al-Zahrawi invented was the **LITHOTRIPTER**, an instrument for **crushing hard deposits in the body, like bladder stones.**

7 A **30-chapter book** written by Al-Zahrawi included illustrations of his **surgical instruments** and explained **HOW AND WHAT TO USE THEM FOR**, making it an **IMPORTANT SURGICAL HANDBOOK** for centuries to come.




8 There were sketches of more than **200 DIFFERENT MEDICAL TOOLS** in Al-Zahrawi's book!

9 AL-ZAHRAWI'S MEDICAL BOOK WAS **translated INTO Latin** SO THAT EUROPEAN DOCTORS COULD LEARN FROM IT.

10  IN THE 12TH CENTURY, A MUSLIM DOCTOR NAMED IBN ZUHR IMPROVED UPON ONE OF AL-ZAHRAWI'S **surgical drills** by adding a **diamond on the tip.**

12 **CATGUT** is a **THIN, NATURAL FIBER MADE FROM THE INTESTINES OF ANIMALS** that can be **absorbed by the body.**

13 CATGUT HAS BEEN USED THROUGHOUT HISTORY TO MAKE STRINGED MUSICAL INSTRUMENTS AND SNARE DRUMS.



11 AL-ZAHRAWI PIONEERED THE USE OF **catgut** for **MAKING INTERNAL STITCHES IN A PATIENT.** SURGEONS STILL USE A SIMILAR MATERIAL.

14

DOCTORS IN MUSLIM CIVILIZATION
TACKLED SERIOUS EYE DISEASES
AND EVEN PERFORMED
eye surgery.



15

Al-Mawsili, a 10th-century Iraqi,
**INVENTED A HOLLOW
NEEDLE** for sucking
cataracts out of
patients' eyes so
they could see again.

16

Muslim scholars produced some
of the **first accurate
diagrams** of the
structure of the
HUMAN EYE.

17

PIONEERING OPHTHALMOLOGISTS OF
MUSLIM CIVILIZATION USED MODERN
TERMS TO DESCRIBE THE ANATOMY OF
THE EYE IN ARABIC, SUCH AS
**retina, uvea,
and cornea.**

CAN OPERATE ON

18

A 15TH-CENTURY
**ILLUSTRATED
MANUSCRIPT**
by Turkish physician
Serefeddin
Sabuncuoglu
showed very
advanced surgery
techniques.



19

SABUNCUOGLU'S
BOOK WAS ALSO THE
FIRST TO SHOW
**FEMALE
SURGEONS**
at work.

20

THREE ORIGINAL,
**HANDWRITTEN
COPIES** OF
SABUNCUOGLU'S
NEARLY 600-YEAR-OLD BOOK
STILL EXIST!

21

Followers of Islam are
**FORBIDDEN TO DRINK
ALCOHOL**, SO PHYSICIANS IN THE EARLY
MUSLIM WORLD HAD TO FIND HERBAL MEDICINES TO
calm their patients.



22

Surgeons in the early Muslim
world described a method for
inhaling drugs
THAT **PUT A
PATIENT TO SLEEP.**

23

**SOPORIFIC, OR SLEEP,
sponges**
WERE USED IN EUROPE
UNTIL THE 1840S.



24

ABU MARWAN ABD AL-MALIK IBN ZUHR, A 12TH-CENTURY
MUSLIM DOCTOR, WAS THE FIRST SURGEON TO PROVE A
TRACHEOTOMY—**A SURGERY IN WHICH A HOLE
IS MADE IN THE WINDPIPE TO AID
BREATHING**—COULD BE DONE SAFELY.

25

IBN ZUHR AND AL-RAZI WERE AMONG THE FIRST DOCTORS TO TEST TREATMENTS ON ANIMALS
BEFORE USING THEM ON HUMANS.

1 From geography to gemstones, scholars developed exciting new ideas about the natural sciences during Muslim civilization.

2 Many areas of science, including geology, meteorology, botany, and zoology, are linked to ideas from a thousand years ago.

3 Scientists in Muslim civilization used observation and experimentation to explore and explain such natural phenomena as earthquakes and the formation of mountains.

4 The boundaries of the Muslim world gave scholars a wide range of geographical regions to study.

5 INFORMATION ABOUT MINERALS, PLANTS, AND ANIMALS WAS GATHERED FROM AS FAR AWAY AS THE MALAY ISLANDS.

6 Al-Hamdani, a 10th-century scholar, wrote three books about ways to look for gold, silver, and other minerals in Arabia.

7 The 11th-century scholar Ibn Sina's *The Book of Cure* presented his observations and theories about how the Earth works.

8 The Latin translation of Ibn Sina's book influenced the study of earth science in Europe for more than 300 years.

9 Al-Biruni, another 11th-century Muslim scholar, took the lead in studies about minerals.

10 Al-Biruni's works included a focus on diamonds, rubies, sapphires, and other gemstones.

11 Like other scientists in the medieval Muslim world, Al-Biruni built upon the work of scholars in earlier civilizations.

12 Al-Biruni classified gemstones by color, shape, and hardness.

13 "Hardness" is the ability of a mineral to scratch the surface of softer minerals.

14 Al-Biruni used crystal shape to help him decide whether a gemstone was a quartz or a diamond.

15 Today scientists and jewelers use similar techniques to identify gemstones.

16 Carnelian, a reddish brown gemstone, is prized by Muslims because the Prophet Muhammad is said to have worn a ring with this stone.

17 Carnelians are often engraved with verses from the Quran.

18 Al-Biruni studied India's Ganges River basin and accounts of other geologic formations from the Baltic Sea to Mozambique.

19 Al-Biruni could speak Greek, Sanskrit, and Syriac and wrote all of his books in Arabic and Persian.

20 BY FINDING FOSSILS OF OCEAN LIFE IN ROCKS HIGH ABOVE SEA LEVEL, AL-BIRUNI PROVED THE OCEAN HAD ONCE COVERED PARTS OF INDIA.

21 Al-Biruni's work became a key reference on precious stones.

22 By observing the moon's effects on the ocean, Al-Biruni figured out that tides changed based on the phases of the moon.

23 Al-Biruni discussed the possibility of the Earth being in motion without rejecting it.

24 Like other scholars of the time he believed the Earth was a sphere and discussed the possibility that it rotates on its axis.

25 Six hundred years later the Italian astronomer Galileo Galilei proved Al-Biruni was correct.

26 Al-Biruni also measured latitudes and longitudes and came up with the concept of antipodes, places that are directly opposite each other on the Earth's surface.

27 ONE OF THE EARLIEST EXPLANATIONS OF WHY THE SKY IS BLUE WAS WRITTEN IN THE 9TH CENTURY BY AL-KINDI.

28 Al-Kindi reasoned that the color midway between darkness and light was blue.

29 Al-Kindi was partly right. The sky is not really blue—that's just the way light acts on the atmosphere.

30 Since ancient times some people have believed that stars and planets had souls and minds.

31 Ibn Hazm, a 10th-century scholar from Córdoba, dared to say that "stars are celestial bodies with no mind or soul."

32 Ibn al-Haytham, another earth science innovator, searched for ways to control flooding along the Nile River. A thousand years later his idea became a reality when the powerful Aswan Dam was completed in present-day Egypt.

33 IBN AL-HAYTHAM'S EXPERIMENTS WITH RAYS OF LIGHT LED TO A DETAILED THEORY OF VISION.

34 His observations paved the way for others to figure out that rainbows are caused by a refraction of sunlight in raindrops.

35 Why does the moon seem to grow in size when it is low in the sky? Ibn al-Haytham said it was a visual trick played by the brain.

36 Later a scholar named Kamal al-Din al-Farisi experimented with glass jars full of water to find out how rainbows are made.

37 Scholars also studied the shape of the Earth, the amount of water versus land, and how rivers, seas, winds, and sea storms formed.

38 Like the ancient Greeks, geographers in Muslim civilization believed the world was round, not flat, and made detailed measurements of the globe.

Sand dunes of Erg Chebbi, in Morocco

75 ROCKIN' FACTS ABOUT

39 Scientists now know that the Earth is slightly pear-shaped.

40 Beginning in the 9th century, people in Muslim civilization made very accurate measurements of the Earth, building on the ancient Greek astronomer Ptolemy's findings.

41 NINTH-CENTURY CALIPH AL-MA'MUN HIRED A GROUP OF MUSLIM ASTRONOMERS TO MEASURE THE DISTANCE AROUND THE EARTH.

42 They measured the distance around the Earth to be 25,012 miles (40,253 km). The current measurement is 24,897 miles (40,068 km) at the Equator.

43 Two centuries later Al-Biruni used an equation to calculate the Earth's circumference that "didn't require walking in deserts."

44 In the early 9th century, mathematician, scientist, and astronomer Al-Battani improved existing values for the length of the year and of the seasons that are very close to today's.

45 Observing the seasons led Muslim scholars to study and calculate the tilt of the Earth on its axis.

46 In the late 10th century, mathematician and astronomer Al-Khujandi built a huge observatory to observe the sun.

47 Al-Khujandi calculated the tilt of the Earth's axis relative to the sun and made a list of latitudes and longitudes of major cities.

48 MUSLIM SCIENTISTS STUDIED WEATHER PATTERNS ON LAND AND AT SEA AND WROTE BOOKS ON METEOROLOGY THAT WERE MUST-READS FOR SAILORS.

49 Ahmed ibn Majid, a great Muslim navigator, learned about currents and the monsoons that helped carry vessels to India.

50 Ninth-century Muslim inventor 'Abbas ibn Firnas invented a weather simulation room in which hidden mechanisms created thunder and lightning.

51 Farmers in Muslim lands followed the *Calendar of Córdoba*, an almanac of weather, planting, and harvesting times.

52 MUSLIM SCHOLARS ALSO EXPANDED THE STUDY OF ANIMALS, CALLED ZOOLOGY, DURING THE 9TH AND 10TH CENTURIES.

53 The most famous Muslim writer on animals was the Iraqi Al-Jahiz, who recognized the influence of environment on animals.

54 Al-Jahiz sometimes rented the contents of entire bookshops so he could read all of the books.

55 Though he wrote poetry and fiction, he mixed in scientific observations about things like camouflage and mimicry.

56 Al-Jahiz also investigated animal behavior and communication, especially among insects.

57 Al-Asmai, an Iraqi scholar, was likely the first Muslim scientist to contribute to zoology, botany, and animal husbandry.

58 Al-Asmai's expertise was in breeding horses and camels.

59 Merino wool, most likely from Morocco, resulted from centuries of careful sheep breeding.

60 Today Merino wool is popular among cyclists, hikers, runners, and other outdoor lovers.

61 The concept of pedigree—tracing the ancestry of an animal, especially the horse—originated in Muslim Spain and is used throughout the world today for all kinds of animals.

62 Arabians, which were originally bred as war horses and for their endurance in the desert, are now one of the world's most popular breeds of riding horses.

63 THE MUSLIM WORLD ALSO MADE SIGNIFICANT ADVANCES IN BIOLOGY, ESPECIALLY IN BOTANY—THE STUDY OF PLANTS.

64 A thousand years ago gardens in Muslim civilization were like scientific field laboratories tended by scholars who took detailed notes about the plants they grew.

65 Migrants to the Muslim world, homesick for their native lands, brought fruit trees, like date and pomegranate, then learned how to grow them in the new climate.

66 Some of the greatest botanists of medieval times came from Muslim civilization.

67 Ibn Bassal, a botanist in Toledo, Spain, came up with a way of classifying ten types of soil and explained which ones were best for raising which crops.

68 Al-Ghafiqi, a physician and botanist from Córdoba, Spain, made herbal medicines from plants he collected in Spain and Africa.

69 Ibn al-Baytar, another botanist of the Muslim world, collected plants and herbs from Spain to Syria.

70 He wrote a book outlining the medical uses for 3,000 plants.

71 Ibn Al-Awwam, a 12th-century scholar from Seville, in Muslim Spain, described in great detail how to grow 585 plants and 50 fruit trees.

72 His book also listed ways to fertilize plants and keep them safe from diseases.

73 The knowledge of plants that botanists in Muslim civilization collected and developed led to the cultivation of many useful, beautiful, and nutritious plants.

74 These plants improved the lives of people in other parts of the world, and they enriched gardens throughout Europe.

75 When Europeans colonized the New World, they brought with them many of the plants discovered, studied, and grown in the Muslim world.

EARTH SCIENCE

15

CRYSTAL CLEAR FACTS



1 Beginning in the 8th century, Egypt, Iraq, Syria, and Muslim Spain produced vast amounts of glassware either by **blowing liquid glass** into molds or by cutting it from crystal.

2 Muslims inherited the Roman glass industry in **Syria** and **Egypt** and improved it by developing their own glassmaking techniques.

3 **Glassmakers** in the Muslim world were skilled in using both blown and **wheel-turned** techniques.

4 They also made many kinds of glass objects, including **bottles**, **vases**, and **cups**.



5 Many amazing examples of ancient glass have been uncovered in excavations of *Al-Fustat*, or "**Old Cairo**," in Egypt.



6 Samarra, near Baghdad, in Iraq, was well celebrated for its glass, especially mosaic glass called **millefiori**.

7 Samarra's glassmakers were also famed for the small, heavy but graceful blue or **green bottles** often used for **perfume**.

8 Many Andalusian **crystal pieces** found their way to churches and monasteries throughout Europe.



Window in the Sultan's room in the Topkapi Palace in Istanbul, Turkey

ABOUT GLASS



9 Finds from *Al-Fustat* include glass weights in **many colors** stamped with the **names of rulers**, some dating from the year 708.



10 Most of what is **known** about Muslim glassware has been learned from **surviving items**, archaeological **digs**, and **writings** of the time.

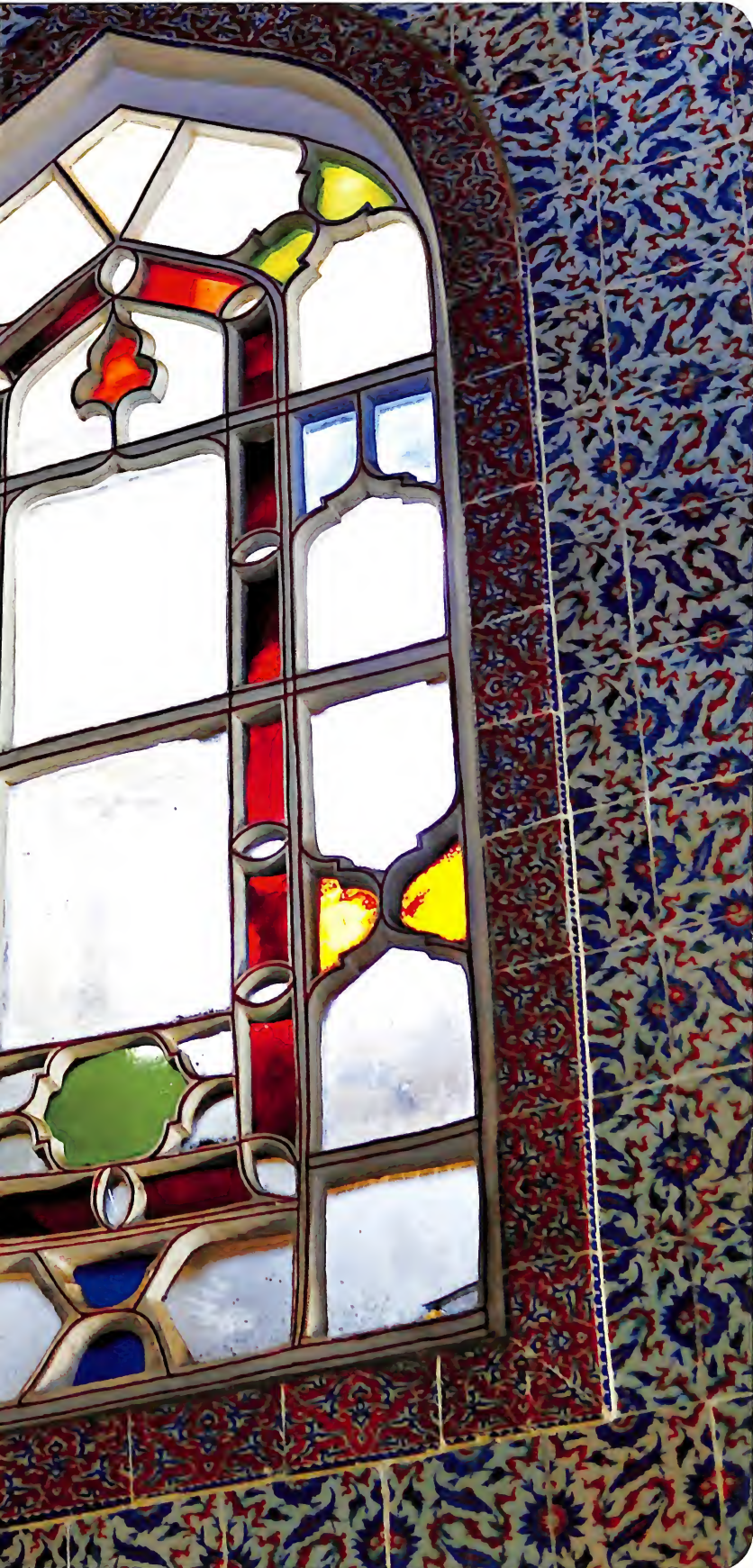
11 A 9th-century Iraqi nicknamed *Ziryab* ("The Blackbird") introduced the use of **crystal glasses** to Muslim Spain after his arrival there.

12 Credit for making glasses out of crystal goes to 'Abbas ibn Firnas, a Cordoban scholar who created a **crystal industry** using rocks mined near Badajoz, Spain.

13 'Abbas ibn Firnas also experimented with using glass **lenses to magnify** the writing in ancient scripts for translators.

14 Ziryab replaced the heavy **metal goblets** and **gold cups** commonly found on the banquet tables of Andalusia in Muslim Spain with delicate crystal drinking glasses.

15 By the 13th and 14th centuries **glassware** from Syria was in **great demand** around the world.



1

Muslim civilization gave rise to many new architectural IDEAS AND STYLES.

2

ENGINEERS in the Muslim world improved upon many architectural features used by earlier civilizations.

3

The Muslim architecture of North Africa and Muslim-ruled Spain is often CALLED "MOORISH" architecture.

4

Architectural advances spread from Muslim-ruled SPAIN AND SICILY to the rest of Europe a thousand years ago.

5

Islamic features in the GREAT MOSQUE OF CORDOBA in Spain made it an inspiration for much of European architecture.

11

Mimar Sinan began as an ORDINARY CARPENTER and ended up designing 477 buildings for three Ottoman Sultans.

12

Sinan's designs emphasized the importance of HARMONY between architecture and landscape.

13

Suleymaniye Mosque, which crowns one of the SEVEN HILLS of Istanbul, Turkey, is one of Sinan's best-known works.

14

Features in Suleymaniye Mosque show that Sinan may have been the FIRST "GREEN" ARCHITECT.

15

Smoke from candles and lamps in the mosque was channeled into a filter room before escaping into the outside air.

21

"Minaret" comes from the Arabic word *manarah*, meaning "lighthouse," a reference to the LIGHT OF ISLAM.

22

Sinan built the Selimiye Mosque in Edirne, Turkey, so well that it has withstood EARTHQUAKES since the 1570s!

23

MATH SKILLS helped Muslims to create many new kinds of arches, including the horseshoe, pointed, and ogee.

24

Architects use arches to SPAN LARGE OPENINGS and carry HEAVY LOADS.

25

The respect Muslims held for the arch is reflected in an Arabic saying that means "THE ARCH NEVER SLEEPS."

35

FACTS TO BUILD ON

Inside of Suleymaniye Mosque in Istanbul, Turkey

6

TRAVELERS, SCHOLARS, and invaders who passed through Muslim lands helped spread Muslim innovations in architecture.

7

Some even took MUSLIM ARCHITECTS AND CRAFTSMEN home with them.

8

Muslim architecture was a symbolic expression of the power of God and the BEAUTY OF LIFE IN PARADISE.

9

Domes, towers, and archways gave buildings A FEELING OF SPACE AND MAJESTY.

10

ROSE WINDOWS in European churches may have been inspired by a circular window in an 8th-century Muslim palace.

16

The soot was then used to make ink that also repelled BOOKWORMS AND BUGS.

17

Sinan figured out a way to MAKE DOMES BIGGER AND HIGHER.

18

Under the Ottomans, domes grew large enough to COVER ENTIRE SANCTUARIES.

19

For Muslims the DOME SYMBOLIZED THE VAULT OF HEAVEN.

20

THE MINARET, a tower used by muezzins to call people to prayer, is an essential feature of a mosque.

26

The HORSESHOE ARCH, which gave a greater feeling of openness, was created by expanding the top of a basic arch.

27

This arch, known in Britain as the "MOORISH ARCH," was popular during Queen Victoria's reign (1837–1901).

28

By tapering the top of an arch, Muslim architects created the POINTED ARCH, which reached Europe by way of Sicily in the early 11th century.

29

The ogee arch, which originated in Muslim India, resembles TWO S-SHAPED CURVES facing each other.

30

The ogee arch, which became known as the "GOTHIC ARCH" in Europe, can be seen in many churches in the West.

31

Muslim architects figured out a way to make VAULTS—arched ceilings—bigger, higher, and fancier.

32

A STALACTITE VAULT, or *muqarnas*, has a dome that looks like a honeycomb.

33

Muslim architects imitated the graceful curve of PALM TREE branches in their designs.

34

THE TAJ MAHAL, in India, is one of the world's most famous and widely visited examples of Islamic architecture.

35

To see all of these architectural innovations under one roof, VISIT THE GREAT MOSQUE in Córdoba, Spain.

WHAT YOU KNOW ABOUT

ARCHITECTURE

15

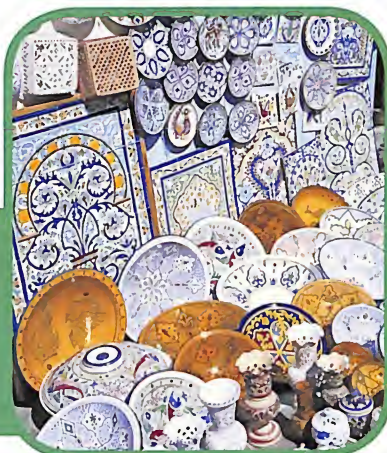
FACTS TO SHAPE YOUR



1 New colors, techniques, and decorations made the pottery of Muslim civilization among the world's finest.



2 Pottery was used for everyday activities, such as **cooking and washing**, as well as for trade and decoration.



3 Everyday pottery was used and then thrown away, much the way we do with paper cups and plates today.

4 One 14th-century historian estimated the value of pottery that ended up daily on trash heaps to be about a **thousand dinars**—about 10 pounds (4.5 kg) of gold!



5 By **adding more lead to their glazes**, Muslims made pots that were **leakproof and able to hold liquid**.

6 Potters in the Muslim world discovered that adding tin oxide to lead glaze produced a **pure white porcelain** similar to that being made in China.

7 **Blue-on-white** decoration became a **signature of the Abbasid potters**.



IDEAS ON POTTERY



Handcrafts for sale in a market in Morocco



- 8 Baghdad and Samarra, Iraq, were among the chief pottery centers in Muslim civilization.



- 9 Three types of pots were most often made: white pots decorated with cobalt blue, pots decorated with two-tone stripes, and pots that had a special metallic luster.

- 10 Eighth-century potters in Iraq revolutionized pottery by developing a process called “luster” that made clay objects look as though they were made of precious metals.

- 11 Islamic law prohibits the use of gold or silver containers, so the luster technique became a way of making luxury items without breaking the law.

- 12 The luster technique was also used to make decorative tiles that made the outsides of mosques and castles appear to shimmer.



- 13 Unglazed pots for everyday use, such as carrying water and eating and drinking, were called *qādūs*.

- 14 Iznik, Turkey, was a thriving pottery center widely known for its blue-and-white tiles even to this day.

- 15 Iznik pottery typically featured floral designs painted on with glazes of cobalt blue, turquoise, and green and then outlined in black with tomato-red highlights.



1

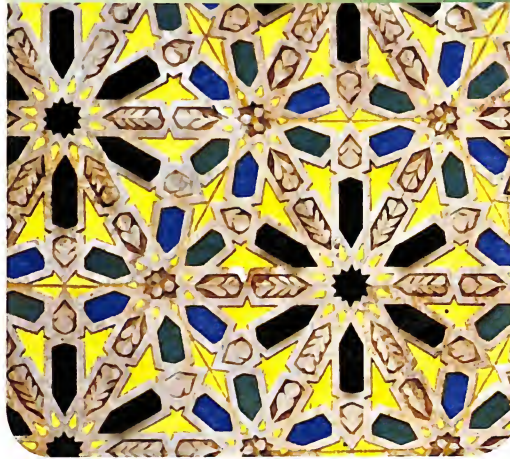
Advances in geometry

CREATED A WHOLE NEW KIND OF ART IN MUSLIM CIVILIZATION.

2

Geometric art

BROUGHT TOGETHER MATH, SPACE, SHAPE, AND PATTERN.



3

Interlacing, flowing lines create complex

PATTERNS THAT SEEM TO CHANGE SHAPE RIGHT BEFORE YOUR EYES.

4

This type of geometric art is called “arabesque.”

5

EACH UNIT OF AN ARABESQUE PATTERN CAN STAND ALONE BUT ALSO HELPS TO COMPLETE THE OVERALL DESIGN.

25

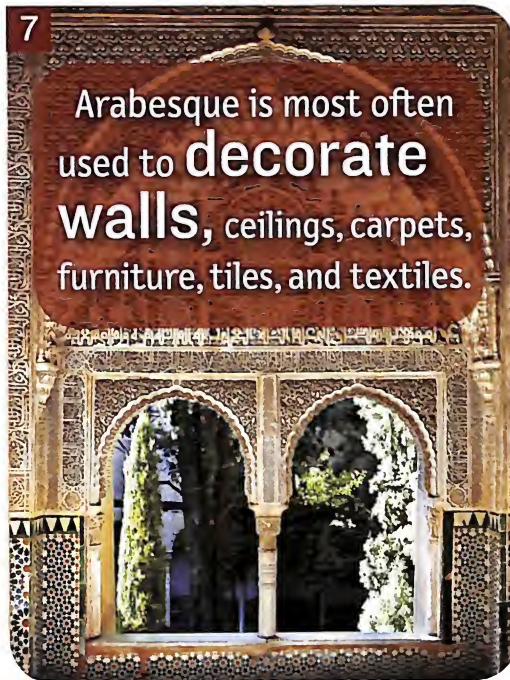
CREATIVE FACTS ABOUT

6

THE COMPLEXITY OF ARABESQUE encouraged **deep thought**, which made it **ideal** for decorating MOSQUES, TOMBS, AND SHRINES.

7

Arabesque is most often used to **decorate walls**, ceilings, carpets, furniture, tiles, and textiles.



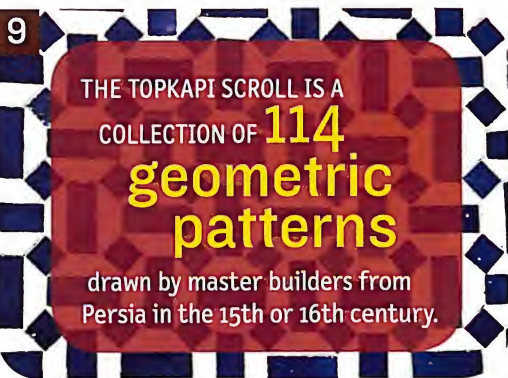
8

MUSLIMS FELT THAT ARABESQUE'S INFINITE DESIGN MOVED BEYOND THE MATERIAL WORLD AND EXTENDED INTO ANOTHER **spiritual level**.

9

THE TOPKAPI SCROLL IS A COLLECTION OF **114 geometric patterns**

drawn by master builders from Persia in the 15th or 16th century.



10

UNLIKE RELIGIOUS ART IN THE WEST, ART IN MUSLIM CIVILIZATION DOES NOT FEATURE HUMANS OR ANIMALS. THE PROPHET MUHAMMAD SPOKE OUT AGAINST PORTRAYING HUMAN OR ANIMAL FORMS IN ART BECAUSE IT IS TOO MUCH LIKE THE WORSHIP OF IDOLS, RATHER THAN OF ALLAH (GOD).



11

ARABESQUE OFTEN USED DESIGNS INSPIRED BY NATURE, ALONG WITH geometric shapes.

12

THIS INSPIRATION INCLUDED THE GOLDEN RATIO, a measurement that appears in nature and is pleasing to the eye.

13

The golden ratio

OCCURS WHEN THE WIDTH OF SOMETHING IS ROUGHLY TWO-THIRDS OF ITS HEIGHT.

14

The nautilus shell is an example of a natural occurrence of a simple and beautiful golden ratio.



17

The ideal **human body** is eight heads long, the **foot and the face** are each an eighth of the body's length, **the forehead** is a third of the face, and the **face** is four noses or four ears. Check yours out!

15

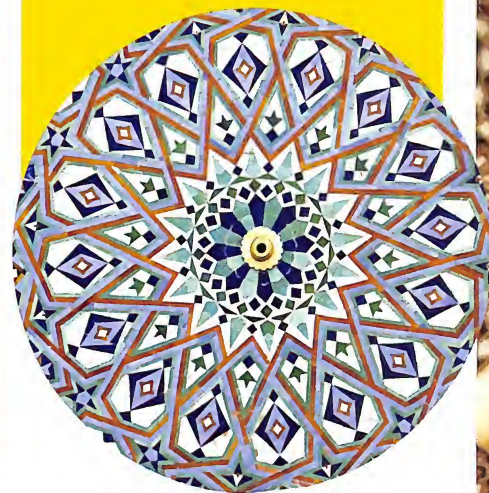
THE IKHWAN AL-SAFA (BROTHERS OF PURITY), A GROUP OF 10TH-CENTURY SCHOLARS, DISCOVERED THAT IF YOU LIE DOWN AND SPREAD YOUR HANDS OUT, YOUR **toes and the tips of your fingers** WILL TOUCH THE EDGE OF AN **imaginary circle**.

18

LEONARDO DA VINCI'S "VITRUVIAN MAN" SHOWS THE PROPORTIONS OF THE HUMAN BODY DESCRIBED BY THE **Brothers of Purity**.

16

Divine proportion and the geometric patterns OF MUSLIM CIVILIZATION HAD AN ENORMOUS IMPACT ON WESTERN ART.



ART AND DESIGN

19

ARABESQUE DESIGNS were often paired with the use of **ARABIC CALLIGRAPHY** to write verses from the Quran.

22

ARTISTS IN MUSLIM CIVILIZATION USED **linseed oil** TO IMPROVE THEIR PAINTS, GLAZES, AND INKS.



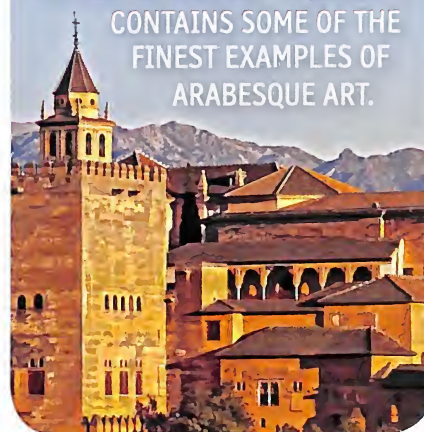
20



Calligraphy IS ONE OF THE MOST RECOGNIZABLE FORMS OF ISLAMIC ART.

21

The Alhambra, a 14th-century palace and fortress in Granada, Spain, CONTAINS SOME OF THE FINEST EXAMPLES OF ARABESQUE ART.



23

BEGINNING IN THE 14TH CENTURY, EUROPEAN ARTISTS STARTED USING **imported linseed-oil paint** INSTEAD OF TEMPERA PAINTS TO ACHIEVE RICHER COLORS.

24

TEMPERA PAINT IS MADE FROM **egg, water, honey, and dye**.



25

M.C. ESCHER, A 20TH-CENTURY ARTIST BEST KNOWN FOR USING GEOMETRIC SHAPES TO **TRICK THE EYE**, WAS INSPIRED BY ALHAMBRA TILE PATTERNS.

15

FABULOUS FACTS



1 The carpets, cushions, and cloths of Muslim civilization are **world-famous** for their quality materials and **jewel-like** colors.

2 By the mid-9th century the **textiles** of Muslim Spain had an international reputation, with everyone from **queens** to commoners seeking out the region's rich, colorful fabrics.

3 Different cities were known for different fabrics. **Córdoba, in Muslim Spain**, housed one manufacturing center with **13,000 active looms**, producing silk for making curtains, shawls, robes, and more.



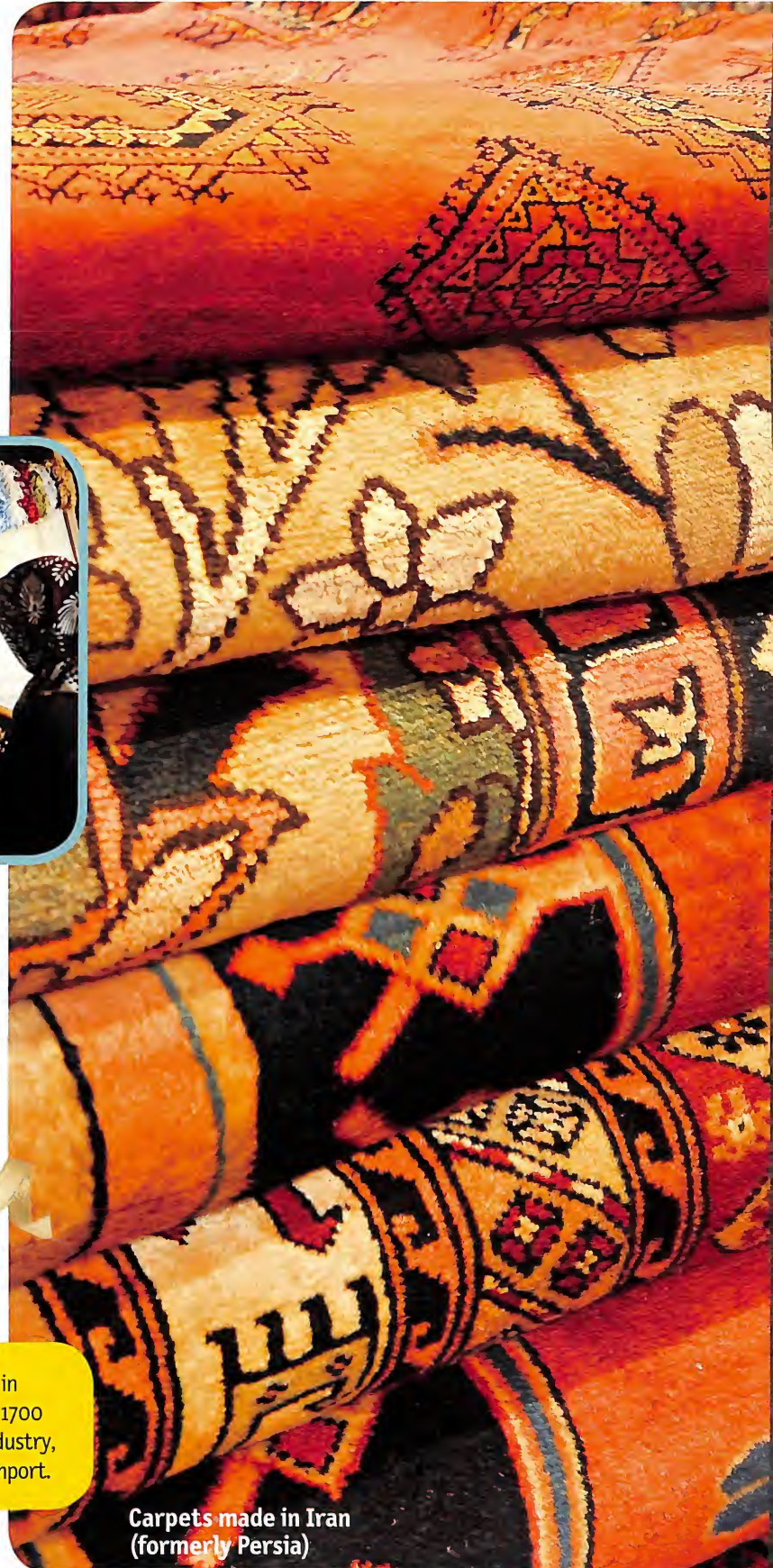
4 Camel, goat, and sheep hair were used to make fabric for clothes, much like camel-hair coats and mohair sweaters worn today.

5 **Muslim silk** was so valued in Europe that Pope Sylvester II was **buried** in Persian silk cloth when he died in 1003.

6 Queen Beatrice of Portugal used silks with **golden borders** imported from Muslim Spain at her wedding in 1383.



7 The **popularity** of Muslim silk in Britain exploded to the point that by 1700 it **threatened** the local textile industry, forcing the government to limit its import.



Carpets made in Iran (formerly Persia)

ABOUT FABRIC

8 Other fabrics were used for **prayer mats**, tapestries, and carpets, while **leather** made in Muslim Spain was sold to European shoemakers.



9 **Nomads** in earlier civilizations used carpets for **shelter** from sandstorms and to create a softer saddle for camel riders.



10 Yellows were made from **saffron** extracted from a crocus flower. Reds came from **qirmiz**, an insect that produced a brilliant red color.

11 **Ibn Badis**, an 11th-century scholar, created inks and dyes that enhanced the rich colors in Muslim carpets and helped to launch them from practical to **fashionable**.



12 Today foods with **red coloring**, like strawberry milk, often contain the extract of **cochineal bugs**, another form of dye introduced by Muslim civilization.



13 Muslim carpets featured bold floral patterns plus shapes like stars, octagons, and triangles arranged in **geometric patterns**.

14 Muslim carpets soon became status symbols, especially in Europe. England's **King Henry VIII** is believed to have owned more than **400 Muslim carpets** and decorated his robes and curtains with Muslim designs.



15 The movie *Aladdin* is based on the folktale about the **flying carpet** of 'Al'a al-Din.



15

NOTE-WORTHY FACTS



1 Muslim civilization learned about paper in 751 from **captured Chinese soldiers**, who passed along the **secrets of papermaking**.

2 It was a lot **cheaper to make books with paper than** with more expensive materials like **parchment or papyrus**.



3 Artists used **reed pens called qalams** and **different colors** of ink to write on paper in a decorative script known as **Arabic calligraphy**.

4 The town of Jativa in Muslim Spain was **famous for the thick, glossy paper** produced in its mills.

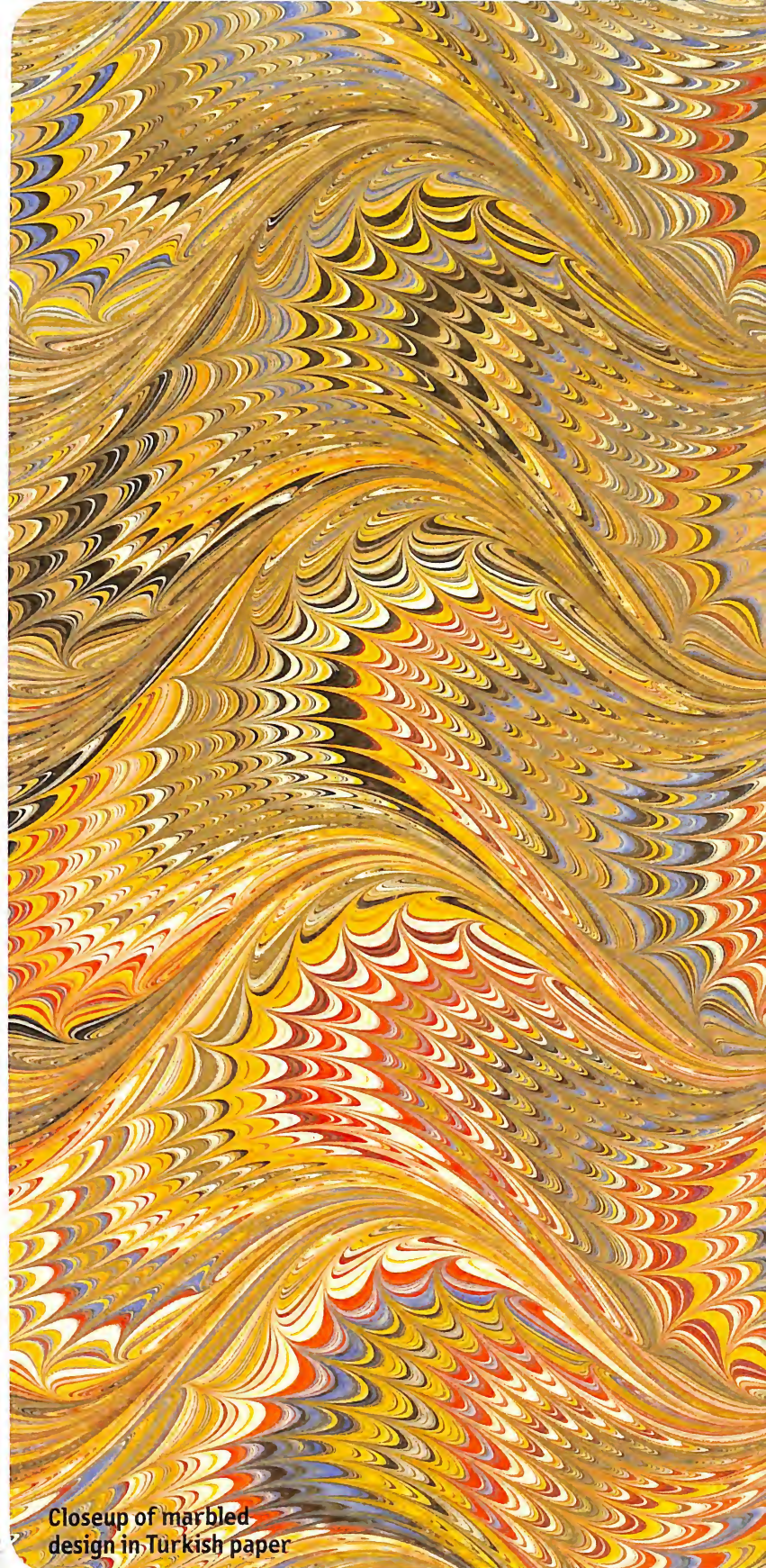
5 Muslim papermakers pioneered the use of the trip hammer, a tool for beating **linen rags or tree roots** into the pulp used to make paper.



6 A large number of **early Arabic manuscripts** dating from the 10th to the 12th centuries are written on paper.

7 The **boom in paper production** meant that thousands of copies of a book could be made, and more books meant more people had the chance to learn.

8 **Hemp**, a crop grown in Syria, turned out to be a great source of low-cost, high-quality paper.



Closeup of marbled design in Turkish paper

ABOUT PENS AND PAPER



9 Today more than **one million books** are published worldwide **each year**.



10 All the **hand mixing and mashing** that went into making paper in China was done by mills in Muslim civilization. Mills **started in Baghdad** and spread to other cities to meet the demand.

11 **Gold and silver inks** were used on blue paper to create impressive front pages for books.

12 In 953 the Sultan of Egypt, **tired of having ink stain his hands and clothes**, asked for a leakproof pen that held its own ink. What he got was much like **today's fountain pen**.



13 **Papermaking** was started in Europe by Muslims living in Spain and Sicily in the 10th century.



14 Muslim artists used **inks and dyes to create patterns** on paper called marbling. By the 1550s marbled paper became prized by Europeans, who referred to it as "Turkish paper."

15 The Muslim world was using **block printing** as early as the 10th century, some 500 years before **Johannes Gutenberg** started printing with moveable letters.

1

Maps made during Muslim civilization usually showed **south at the top** and **north at the bottom**—**UPSIDE DOWN TO A WESTERN VIEW TODAY.**

2

THE CHINESE INTRODUCED **paper** to Baghdad in the 8th century, which **MADE IT POSSIBLE FOR THE MUSLIM WORLD TO CREATE MAPS FOR EVERYONE TO USE.**

3

In the 9th century, astronomers in the Muslim world were **SO ACCURATE IN THEIR CALCULATIONS OF THE EARTH'S CIRCUMFERENCE** THAT THEY WERE ONLY 125 MILES (201 KM) OFF THE 24,897 MILES (40,068 KM) ACCEPTED TODAY.



4

In 1073 Turkish geographer Mahmud al-Kashghari created **A CIRCULAR WORLD MAP** showing where various languages were spoken.

5

In 1154 the Muslim geographer Al-Idrisi finished **the first atlas**, which showed most of North Africa, Asia, and Europe. This was about a hundred years before Marco Polo wrote about his travels to China and back.



25

GLOBAL FACTS

6



AL-IDRISI SPENT **15 years** CREATING **70 maps** for the atlas of Roger II, King of Sicily.

7

Christopher Columbus studied maps created by Muslim geographers to make the voyages that helped him to reach the Americas.



8

Ibn Majid, **A MASTER NAVIGATOR FROM ARABIA**, guided the Portuguese explorer **Vasco da Gama** around Africa's Cape Horn to India in the 15th century.

11

The Book of Sea Lore, which included more than **200 charts and maps**, was a guide to the coasts, islands, ports, and waterways of the Mediterranean.

9

The **earliest known** description of a **magnetic compass** is in a collection of stories written by the Persian Muhammed al-Awfi in 1233.



10

One of the most important navigators of the 16th century, Turkish admiral **PIRI REIS**, wrote a manual of sailing directions called **THE BOOK OF SEA LORE.**

12

Originally printed in **1521**, *The Book of Sea Lore* was a **must-read for navigators** for more than a century.

13

Piri Reis is best known for the incredibly accurate “MAP OF AMERICA” HE CREATED IN 1513.

14

The “MAP OF AMERICA” was compiled using numerous other maps, including Arab and Portuguese ones and one made by Columbus on his third voyage to the THE AMERICAS.



15

The Columbus **map** that Piri Reis used **was lost** after Columbus sent it to Spain in 1498, so the Piri Reis version is the **only record** we have of it.

16

THE “MAP OF AMERICA” SHOWS MOUNTAINS (NOW CALLED THE ANDES) IN SOUTH AMERICA THAT SPANISH EXPLORERS CLAIMED TO HAVE FOUND FIRST IN 1527—14 YEARS AFTER PIRI REIS MADE HIS MAP.

17

PIRI REIS DREW HIS “MAP OF AMERICA” ON THE HIDE OF A GAZELLE, A KIND OF **African antelope**.

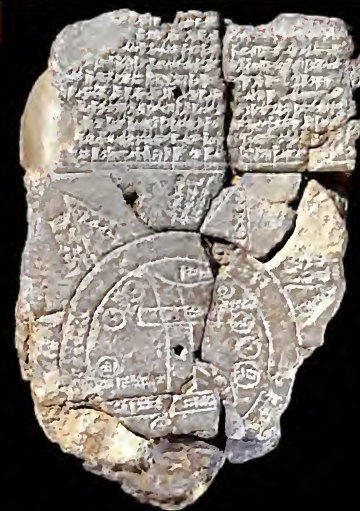


ABOUT GEOGRAPHY

18

Piri Reis drew a **second map** covering the northwestern part of the Atlantic Ocean, including **NEWFOUNDLAND**, on Canada’s east coast.

19



The earliest known maps were inscribed on **clay tablets** MORE THAN 3,500 YEARS AGO IN BABYLON.

20

Building on the work of the Romans, scholars in Muslim Spain created **triangulation**, A METHOD STILL USED TO SURVEY LAND AND CREATE MAPS.

21

Muslim sailors weren’t lost at sea BECAUSE THEY DEVELOPED COURSE-PLOTTING INSTRUMENTS AND BECAME MASTER NAVIGATORS.

22

TO CHART THE EARTH’S FEATURES, GEOGRAPHERS IN THE EARLY MUSLIM WORLD USED ASTROLABES, INSTRUMENTS THAT CALCULATE HEIGHT AND DISTANCE.

23

Trouble finding your way? THE NAVIGATION TECHNIQUES OF THE PAST HAVE ALL CONTRIBUTED TO MODERN DIRECTIONAL DEVICES LIKE GLOBAL POSITIONING SYSTEMS (GPS).

24

Today’s **GPS** is **extremely accurate**.

A 2011 STUDY SHOWED THAT GPS IS OFTEN ACCURATE TO WITHIN 3 FEET (1 M).



25 Want to know how people saw the world 1,000 YEARS AGO? Take a look online at *The Book of Curiosities*, written in Egypt in the 11th century (see page 92).

1

People in Muslim civilization **loved to travel and learn**. "Seek knowledge even from as far as China," the Prophet Muhammad commanded his followers.

2

The Palestinian geographer Al-Muqaddasi **explored almost every corner** of the 10th-century Muslim world, making observations and taking notes.

3

Thanks to journals kept by Muslim travelers and geographers, we know what life was like in the **medieval world**.

4

Al-Dimashqi, a 14th-century geographer, told about life on the Malay Islands, where towns and cities were surrounded by **dense forests**.

5

The **giraffe** was introduced to China from Africa, thanks to Zheng He's voyages.



6

Al-Dimashqi's accounts said a giant bird called *al-Rukh* and **white elephants** lived on the Malay Islands.

7

Imagine having to find your way to Mecca on foot or by camel **without a map!** That's why early Muslims needed a strong knowledge of geography and astronomy.

8

According to Islam, it is the duty of all able-bodied Muslims to give every effort to make at least one **hajj**, or pilgrimage, to Mecca.

9

Hajj is an Arabic word meaning "to set out for a place."

10

Many Muslims expanded **geographic knowledge** by writing about the people and places they saw while on their **hajj**.

11

Since the 7th century people have traveled thousands of miles on **horseback**, camel, or by foot to make the **hajj**.

12

Traders and travelers wrote some of the first detailed Arabic descriptions of **China**.

13

Many famous **European explorers** used maps and information from the Muslim world.

14

In addition to travel by land, Muslim traders **sailed the seas** to foreign lands, gaining new knowledge of sea routes.

15

In the late 800s, Al-Ya'qubi described in his *Book of the Countries* the color, breezes, and fish in the **seven seas** he'd have to cross to reach China.

16

Before the 15th and 16th centuries **Vikings** were the only Europeans who are positively known to have traveled great distances by sea.



17

Ibn Khurradadbih wrote a book about the main Muslim **trade routes**, which included China, Japan, Korea, and Java.

18

He mentioned "**Waqwaq**" islands (probably present-day Japan), lying "East of China."

19

The Arab Ibn Fadlan traveled to northern Europe in 921, where he met European merchants he described as "tall as date palms" camped along the **Volga River**.

20

Travelers' tales of **sea monsters** and giant land animals led to the creation of elaborate Arabic folk tales, such as *The Thousand and One Nights* and *The Seven Voyages of Sinbad the Sailor*.

21

Ibn al-Jazzar, a 10th-century doctor, wrote *Traveler's Provision*, a guide to **medical problems**—useful at home and on the road.

22

Reconstruction of Baghdad's **medieval canals** in 1895 wouldn't have been possible without the detailed descriptions of a 10th-century geographer named Suhrah.

23

Scholars in Muslim civilization believed, as did the ancient Greeks, that the **Earth was round**.

24

Using his own notes, travel accounts, and the work of earlier scholars, Al-Idrisi created a comprehensive **atlas** of the 12th-century world.



25

In 1325 a 21-year-old Moroccan named Ibn Battuta set out for Mecca on a journey that would last **29 years** and take him to the four corners of the known world.

26

Ibn Battuta traveled more than **75,000 miles** (120,000 km) and met thousands of people, including many rulers and leaders.



27

Of the **44 countries** that Ibn Battuta visited he called China "the safest and best country" for travelers.

28

Ibn Battuta's account of life in medieval Mali, West Africa, is the **only record** we have today of the area at that time.

29

Ibn Battuta is often called the **Muslim Marco Polo**.

30

The world's largest themed shopping mall, which is in **Dubai**, United Arab Emirates, is named after Ibn Battuta.

31

In 1271 Marco Polo was only **17 years old** when he left his home in Venice, Italy, to travel to China and back—a 24-year-long journey.

32

One of history's record-breaking naval explorers was a 15th-century Mongolian Muslim from China known as **Zheng He**.

33

Zheng He was named **Admiral of the Chinese fleet** and traveled to 37 countries between 1405 and 1433.



36

Each of Zheng He's ships could have a crew of up to **500**.



39

When Zheng He's navy was on the move, it **resembled a small city**.

40

His first fleet included **27,870 men** on **317 ships**.

43

Zheng He's ships were often called "swimming dragons" because they were decorated with **dragon eyes** to help them "see."

46

Zheng He's fleet included tankers that carried **fresh water** for drinking.

47

The seven voyages that Zheng He made in the name of trade and diplomacy were called the "**Treasure Ship**" voyages.

48

In 1962 a rudder post of a **treasure ship** was found in an old boatyard in China. It was 36 feet (11 m) long—suitable for a boat 500 feet (152 m) in length.

50

Facts About

EXPLORATION

34

Zheng He was not only a powerful man but also a striking figure. Some accounts say he weighed more than **220 pounds** (100 kg) and was more than **6.5 feet** (2 m) tall, with a stride like a tiger's.



37

Some ships in Zheng He's fleet were more than **400 feet** (122 m) long and 180 feet (55 m) wide.



38

By comparison, Columbus's ship **Nina** was only 75 feet (23 m) long.

41

Flags, lanterns, and even carrier pigeons were used to **communicate** between ships and coordinate the fleet's movements.

44

Zheng He's ships carried all kinds of live animals, including celestial horses (zebras), celestial stags (oryx), and camel-like birds (ostriches).

49

Zheng He's journeys were a great success—not only in the search for **new minerals, medicines, and species** but also in drawing tribute from many of the nations with whom he traded and made diplomatic links.

45

Working in pairs, **otters** were used to herd fish into nets to help feed the large crews.

42

Modern shipbuilders don't know how these floating cities were **made without metal**.

50

Ironically, less than a **hundred years** after Zheng He's death in 1433, China banned seagoing trade and multimast sailing ships.

Camel caravan crossing the Sahara near Morocco



15

TANTALIZING TIDBITS



- 1 From the time they were used by nomadic Arab desert dwellers, tents have served as shelters and meeting places.

- 2 Tents of the Ottoman Turks were elaborately decorated royal structures used for practical and social occasions, such as grand parties and ceremonies.

- 3 Whether traveling for war or hunting trips or to any kind of ceremony, the Sultan always had his tent with him.



- 4 During travel or a military campaign large tent cities were formed. There were royal tents for the rulers and lesser tents for ordinary people and soldiers.



- 5 Military tents sometimes had different colors, which may have been a way to tell regiments apart.

- 6 The Wawel tent collection in Krakow, Poland, has an oval tent with a diameter of 79 feet (24 m) and a height of 12 feet (3.7 m).

- 7 Inspired by Turkish royal tents, French King Louis XIV had many ceremonial tents. This helped to create a tent craze across Europe in the late 17th century.



Bedouin camp in the Sahara



ABOUT TENTS



Ottoman tent-pole
banner holders,
8th century

8 One account about a Sultan's travels says that it took **600 camels** just to carry the tents!



9 The round, domed tents used by Ottoman Turks may have been inspired by **yurts**, felt tents still used by **nomads** in Mongolia and Central Asia.

10 The Ottomans were also inspired by **Persian and Byzantine** tent creations and created their own tent design style and furniture.

11 Turkish royal tents had brightly colored **silk crowns**, richly patterned **carpets** and **cushions**, and raised sections to add majesty.

12 Today visitors can experience the **beauty and grandeur** of these kinds of tents at the Royal Castle of Wawel in Krakow, Poland.



13 **Two tents** always accompanied a Sultan on his travels: one to live in **during a stop** and another for tent pitchers to **march ahead** and set up in the next location.

14 Royal tents were called "**walled palaces**."

15 **Tents were often very large**. One tent built in 1744 in Vauxhall Gardens, London, England, had a dining area with 14 tables!



15

RICH FACTS ABOUT



1 Trade was a major part of life in early Muslim civilization, and goods were bought and sold across three continents.

2 Trade was so important that Muslim rulers created laws, contracts, loans, and more, which still influence trade today.

3 Buyers and sellers in Muslim civilization used checks! The word “check” comes from the Arabic *ṣakk*, which is a written vow to honor payment for merchandise upon delivery.

4 Ever wonder where the idea for a rest stop came from? In the Muslim world important trade routes had rest stops called “caravansaries” about every 19 miles (30 km).



5 Caravansaries provided free food, shelter, and entertainment to travelers for up to three days.

6 Land trade was mainly along the Silk Route, a 7,000-mile (11,265-km)-long trade route linking China to markets in the Muslim world and Europe.

7 Lots of items traded in the Muslim world were highly prized, such as textiles, metal, tooled leatherwork, carpets, illustrated manuscripts, enameled glass, and soaps.



Silk scarves in a bazaar

TRADE AND MONEY



- 8 Many cities **gave their names to the famous goods they produced**: muslin from Mosul, Iraq; gauze from Gaza; and damask cloth from Damascus, Syria.

- 9 **Giant camel caravans** traveled enormous distances **to trade** with foreign lands.



- 10 **What's that smell you say?** Don't get too close to the campfires because while on caravan, travelers used dried animal dung as fuel!

- 11 Traders in the Muslim world used **gold and silver coins**, called "**dinars**" and "**dirhams**," as international currency.

- 12 **The first Caliph to create his own coins** was Caliph Abd al-Malik ibn Marwan, who ruled from 685 to 705. His were also the **first gold coins** to carry an **Arabic inscription**.



- 13 Trade with Maldivian Islanders, who paid for goods with **cowrie shells**, spread the use of this form of currency to distant areas of the Muslim world.



- 14 It is believed that **two giant gold Islamic coins** existed in the early 1600s. One of these coins was 8 inches (20 cm) in diameter and weighed in at 26.5 pounds (12 kg) of **pure gold**!

- 15 **Coins from the medieval Muslim world** have been found in modern-day Germany, Finland, and Scandinavia, showing how widespread trade was during this time.



15

SPARKLING FACTS



1 Muslim civilization gave rise to a thriving industry of **mining rubies, emeralds, sapphires, and other precious stones.**



2 About **a thousand workers mined cinnabar** to make mercury in Almadén, in Muslim Spain.

3 **Egypt was a great source of emeralds,** while carnelian and onyx were mined in Yemen and Muslim Spain.



4 The largest and most famous sapphire in the world is the Star of India. **It is 563 carats!**

5 Beginning in the 14th century **divers harvested precious pearls** in the Persian Gulf and the Arabian Sea.

6 **Pearl divers would tie a rope around their waist and swim to the bottom of the sea to collect oysters containing pearls.** When they ran out of breath, they would tug on the rope to be pulled up to the boat again.

7 **Big or small? Pearls** can be found in lots of **different sizes and colors.**



8 **Coral** was collected from reefs off the **COAST** of North Africa near Sicily and Sardinia.



An aigrette, or ornament, with pearls, diamonds, and emeralds from a late 17th-century Ottoman headdress

ON JEWELS



- 9 Today **coral mining is banned** in many countries around the world.



- 10 People loved to use pearls and coral to make prayer beads, jewelry, and to **adorn their weapons**.

- 11 Precious stones were **polished with emery** found in Nubia and Ceylon (now Sri Lanka).



- 12 One of the **precious items mined** was salt, which was referred to as **"white gold"** in the Muslim world.



- 13 **Huge camel caravans carried salt** from mines in Yemen, Persia, Armenia, and North Africa to markets far and wide.

- 14 Pictures of natural things, such as **leaves or flowers**, were often used as inspiration for jewelry designs.

- 15 Today because **coral is so scarce**, beads made with it are **very expensive**. A single, 2-inch (50-mm) bead can cost as much as \$50,000.



1 THE CHINESE DISCOVERED HOW TO MAKE **SALTPETER** (POTASSIUM NITRATE), A KEY INGREDIENT IN **GUNPOWDER**, IN THE 1ST CENTURY.



4 THE USE OF GUNPOWDER BY ISLAMIC ARMIES WAS A MAJOR ADVANTAGE IN THEIR BATTLES AGAINST THE CRUSADERS, CHRISTIAN ARMIES TRYING TO OVERTHROW MUSLIM CONTROL OF JERUSALEM FROM THE 11TH TO 14TH CENTURIES.

2 Although the Chinese used gunpowder to put on **great fireworks shows**, they could not figure out the correct proportions to make powerful explosions.



3 CHEMISTS IN MUSLIM CIVILIZATION IMPROVED UPON THE WORK OF THE CHINESE AND FOUND A WAY TO USE GUNPOWDER TO CREATE STRONG EXPLOSIONS FOR FIREARMS.

5 Muslim civilization improved on the **design of cannons** that could be held in your hand.



25

FACTS ABOUT WAR AND WEAPONS

6 Muslim civilization was the first to make huge **SPLIT-BARREL GUNS**.

9 MADE OF BRONZE, THE CANNON WEIGHED **18 tons** and was so long it had to be cast in two pieces and screwed together.



7 Fifteenth-century Ottomans had **LARGER AND MORE POWERFUL CANNONS** THAN ANY BEING USED IN EUROPE AT THE TIME.

10 A DECORATIVE INSCRIPTION in Arabic was made on the **muzzle** of Sultan Mehmed's cannon.

11 OVERALL, THE CANNON WAS MORE THAN 17 FEET (5 M) LONG AND 2 FEET (.6 M) IN DIAMETER WITH A BARREL THAT WAS ALMOST 10 FEET (3 M) LONG.

12 Able to **FIRE A CANNONBALL UP TO A MILE**, no cannon as impressive had ever been built before.

8 The **largest** of these cannons was ordered by Ottoman Sultan Mehmed II in 1453 during the **siege of Constantinople**.



13 In 1867 **Queen Victoria** requested Sultan Mehmed's cannon to show in England. At the time it was known as "**the most important cannon in Europe**."

14 SULTAN ABDUL AZIZ gave Queen Victoria Mehmed's cannon as a gift, and it is now on display in the Fort Nelson Museum, in Portsmouth, England.



SULTAN MEHMET'S CANNON IS NOW PART OF THE COLLECTION OF THE ROYAL ARMOURIES, ALONG WITH 70,000 other examples of weapons from ancient times to the present.

16 A 13TH-CENTURY SYRIAN SCHOLAR NAMED HASAN AL-RAMMAH WROTE ONE OF THE MOST IMPORTANT BOOKS ON MILITARY TECHNOLOGY, THE BOOK OF HORSEMANSHIP AND INGENIOUS WAR DEVICES.

17 Al-Rammah's book was packed full of **DIAGRAMS OF WEAPONS**, including the first description of a military rocket.

18 Another diagram in Al-Rammah's book was of the **first torpedo**, a kind of rocket made to skim along the surface of the water.

TO BATTLE WITH

19 THE **pear-shaped torpedo** WAS MADE OF IRON AND GUIDED BY **two rudders**.

20 The torpedo carried a **MIXTURE OF EXPLOSIVES** and **IRON FILINGS**, sealed with a layer of felt.

21 WITH A SPEAR AT THE FRONT, THE TORPEDO WOULD LODGE IN THE WOODEN HULL OF AN ENEMY SHIP BEFORE THE EXPLOSIVES DETONATED.

22 IN MUSLIM CIVILIZATION THIS TORPEDO WAS CALLED **"the egg, which moves itself and burns when it hits the target."**

23 Al-Rammah's book **FEATURED A TREBUCHET**, a weapon used for **flinging missiles**.



24 The book by Al-Rammah described **DOZENS OF RECIPES FOR MAKING EXPLODING GUNPOWDER**.



25 THE NATIONAL AIR AND SPACE MUSEUM IN WASHINGTON, D.C., U.S.A., HAS A MODEL OF WHAT AL-RAMMAH'S ROCKET MAY HAVE LOOKED LIKE IN ITS COLLECTION.

1

During the 800 years in which the Muslims ruled Spain, THEY BUILT INGENIOUS CASTLES.

2

Following a practice called *SPOLIA*, some early Islamic castles reused older masonry from Roman structures.

3

To WITHSTAND A SIEGE, some cities in Syria and elsewhere in the early Muslim world had castles, high walls, and gates.

4

Governors of towns lived in castles called "CITADELS," usually built on high land at the city's edge.

5

Citadels were often surrounded by walls, and each was LIKE ITS OWN CITY, with a mosque, guards, offices, and living spaces.

11

The military defenses and CASTLES IN JERUSALEM and other Muslim strongholds impressed the Crusaders from Europe.

12

Crusaders took the NEW ARCHITECTURAL IDEAS HOME with them and used them in their own buildings.

13

During peace times CRAFTSMEN FROM EUROPE were sometimes hired by Muslims to help them repair or build castles.

14

Greeks and Romans used arrow slits, but Muslims IMPROVED THE DESIGN and made them standard features in their castles.

15

Arrow slits allowed bowmen to shoot out but PROTECTED THEM from return fire.

21

BATTLEMENTS are a series of cutouts and raised sections on the top walls that provided cover for defenders.

22

Today battlements are used as DECORATIVE FEATURES in certain styles of architecture.

23

European castles built after the Crusades used many of the DEFENSIVE FEATURES of Muslim castles in the Middle East.

24

HEARST CASTLE in California combines several architectural styles, including Mexican, Baroque, and Islamic.

25

Islamic castles often had very LARGE WATER STORAGE CISTERNS.

Citadel in Aleppo
(now Halab), Syria

35

FACTS TO FORTIFY

6

Keeps, arrow slits, barbicans, machicolations, parapets, and battlements were **KEY FEATURES** of Muslim strongholds.

7

The central, fortified tower within a castle is called a **KEEP**.

8

While Muslim keeps were usually **ROUND**, keeps in Christian Europe were **SQUARE**.

9

THE TOWER OF LONDON is probably the most famous example of a European castle with square towers.

10

From a round tower the enemy could be seen from any direction, and there were **NO CORNERS** for attackers to hide behind.

16

A **BARBICAN**, a walled entrance passage, helped to confine enemies so defenders could attack them from above.

17

The word "barbican" is taken from the Persian *bab al-khanah*, meaning "**GATE HOUSE**."

18

The stone walls of castles were **REINFORCED WITH WOOD BEAMS** as steel is used to reinforce walls today.

19

MACHICOLATIONS are holes or gaps in the overhanging floor of a parapet, the open walkway around the top of a castle.

20

Muslim defenders used machicolations to **DROP BOILING OIL**, molten lead, and even missiles on their attackers!

26

During the 14th and 15th centuries **THE ALHAMBRA** was built as a military complex overlooking Granada, in Muslim Spain.

27

The Alhambra takes its name from an Arabic word meaning "**THE RED CASTLE**," or "the red fort."

28

The fortress section of the Alhambra, dating from the 12th century, is referred to as **THE ALCAZABA**.

29

The Alcazaba was the **MILITARY HEADQUARTERS** for the Nasrid, the last Muslim dynasty in Spain.

30

The most significant watchtower at the Alcazaba is the 87-foot (29-m)-high **TORRE DE LA VELA**.

31

"Alcazaba" is taken from the Arabic word *al-qasbah*, meaning "**A WALLED FORTIFICATION**" in a city.

32

Albarrana towers—detached towers connected to the outer walls by a bridge—were another **MUSLIM INNOVATION**.

33

ALBARRANA TOWERS first appeared in castles in Muslim Spain in the 12th century.

34

The word "albarrana" is derived from the Arabic *barrani*, which **MEANS "EXTERIOR."**

35

Albarrana towers **WERE RARELY USED** outside Muslim Spain.



YOUR KNOWLEDGE ABOUT CASTLES AND KEEPS

15

CRYPTIC FACTS ABOUT

- 1 Have you ever cracked a code?
Bet you didn't know you could trace many code-breaking techniques to Muslim civilization.

- 2 In 9th-century Muslim civilization mail was sent by carrier pigeon, giving new meaning to the term "air mail"!

- 3 Because of the use of birds for mail in the Muslim world, confidential messages needed a way to be kept private, so encryption, or coding, was used.



- 4 The citadel in Cairo, Egypt, which was the communication nerve center of the time, had about 1,900 pigeon "mailmen."
- 5 By studying the Arabic text of the Quran, Al-Kindi, a 9th-century scholar from Baghdad, noticed that certain letters were used more frequently than others.



- 6 He used this observation to come up with a code-breaking method based on what he called "frequency analysis."

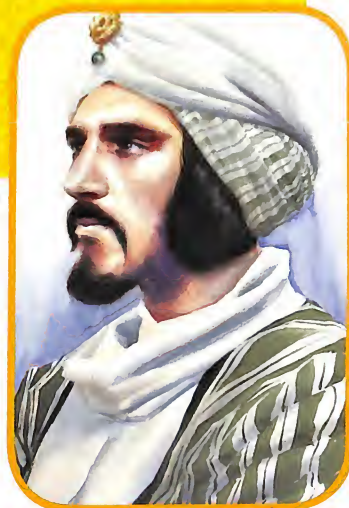
- 7 In this kind of code, letters are replaced by symbols or other letters. A decoder can figure out what the letters or symbols stand for, substitute other letters for the symbols, and read the message.

- 8 If a message written in English were encoded using this method, the most common symbol would represent the letter e since it appears most frequently.

e



COMMUNICATION



9 Al-Kindi's book, *Treatise on Deciphering Cryptographic Messages*, laid the foundations for **modern cryptology** by encouraging people in other cultures to figure out new ways to encode messages.

10 Frequency analysis using substitution ciphers became the basic tool for breaking codes that used a **text alphabet**.

11 Before Al-Kindi's work, many thought that substitution ciphers were **unbreakable**.

12 "Cryptanalysis" is the 20th-century word for the **study of codes and ciphers** begun by Al-Kindi.

13 Using **cryptanalysis**, the Allies in World War II were able to decipher German military encryptions made by a typewriter-like machine called "Enigma."

14 The **Germans' secret messages sent by Enigma** were decrypted by Polish and British code breakers.

15 Journalist Simon Singh names **Al-Kindi** as the originator of the first method of **code breaking** in *The Code Book*, published in 1999.



1

Farmers in the 9th-century Muslim world launched an **AGRICULTURAL REVOLUTION** when they began using new methods to grow crops.

2

During Muslim civilization people **TRAVELED** as far east as China and as far west as Spain, seeking new knowledge about agriculture and botany.

3

This new information was **CATALOGED** in huge agricultural manuals for all to read.



4

These **MANUALS** taught farmers how to raise the finest animals, **GROW NEW SPECIES** of plants, irrigate fields, use fertilizers, and fight **PESTS**.

5

The agricultural system in the early Muslim world was one of the most **COMPLEX AND SCIENTIFIC** ever devised.

6

The changes in agriculture **IMPROVED** the economy, city growth, **LIFESTYLES**, cooking, clothing, and more.

7

12th-century botanist Ibn al-Awwam **BUILT UPON STUDIES** of Egyptian, Greek, and Persian scholars to develop his *Book of Agriculture*.

8

Ibn al-Awwam's book was a **HOW-TO GUIDE FOR FARMERS** on everything from how to grow trees to beekeeping.

9

His book also had tips about how to keep pests away from **CROPS** and even told people how to **COOK** the food they grew.

10

Farmers in the Muslim world learned how to **GROW** different crops in different seasons on the same land. This is called "**CROP ROTATION**."

11

Crop rotation, the use of giant waterwheels called **NORIAS**, and the development of the water pump made it possible to grow new crops and have four harvests each year.

12

Rice, **CITRUS FRUITS**, plums, apricots, artichokes, saffron, and **SUGARCANE** were among the new crops grown in the Muslim world.

13

Rice, sugarcane, and cotton require a lot of **WATER TO GROW**.

14

It reportedly took **8,000 NORIAS** to supply water to all the rice plantations in Valencia, in Muslim Spain.

15

Using underground canals called **QANATS** to transport water kept it from evaporating.

16

Canals brought **WATER** from snowcapped **MOUNTAINS** to fields in the dry climate of Andalus, in southern Spain.

17

Year-round fresh fruit and veggies meant **HEALTHY EATING** for more people.

18

Rice mixed with butter, oil, fat, and milk became a **FAVORITE FOOD**.

19

There were even **COOKBOOKS** full of rice recipes.

20

Today **RICE** is eaten by more people than any other kind of grain.

21

U.S. farmers produce more than **20 BILLION POUNDS** of rice each year.

22

COTTON from India was imported to Sicily and Spain by Muslims and became a major crop.

23

The spread of cotton, silk, and wool gave people a choice in what kind of clothes **TO WEAR**.

24

The **COTTON PLANT** is called *algodon* in Spanish, from the Arabic *al-qutn*.

25

SUGARCANE found its way to Zanzibar, Ethiopia, and Spain thanks to Muslim traders.

26

Today some of the **BEST SUGAR** comes from Zanzibar, now part of Tanzania in East Africa.

27

The word "**CANDY**" comes from the Persian *qand*, meaning "sugar" or "sweet."

28

Baskets and floor coverings were made from **ESPARTO GRASS**, which grows wild in parts of Spain.

29

A fig tree cutting from what is now Jordan planted in Muslim Spain grew so well that more cuttings were made, and soon **FIG TREES** spread across all of Spain.

30

Oranges, lemons, and limes may not have become so popular in the **WESTERN WORLD** without the orchards in Muslim lands.

31

The average person will eat **12,888 ORANGES** in a lifetime.

32

ORANGE TREES from India were **PLANTED** in Jordan, Iraq, Syria, Turkey, Palestine, and Egypt.





33

Fresh or dried figs are a good source of sugar, and **DRIED FIGS** stay fresh for more than a year.

36

A camel can be as tall as a **BASKETBALL HOOP** is high and weigh as much as three motorcycles.

39

The *Calendar of Córdoba* of 961, written by Ibn Bassal, was like a **FARMER'S ALMANAC**. It told when to plant, water, and harvest.

42

Farmers no longer had to do whatever big **LANDOWNERS** demanded.



45

Farmers spread **PIGEON DROPPINGS** on their fields for fertilizer.

46

Pigeons were housed in **CUBBYHOLES** in huge mud-brick structures called **PIGEON TOWERS**.

47

RUINS of pigeon towers still stand in the Middle East.



48

Farmers fed **MILLIONS OF PEOPLE** in Muslim Spain, equal to a large proportion of the population of **EUROPE** at the time.

49

Sugarcane, cotton, and rice were brought to the **AMERICAS** from Spain and Portugal after the end of Muslim rule there.

50

French, British, and Dutch **COLONISTS** made their fortunes in the Americas by growing these crops.

34

The oldest known **FIG TREE** is **2,300 YEARS OLD**.

40

The **CALENDAR** told farmers that in March roses would bloom and quails would appear. It was also the **TIME** to plant cucumbers and eggplants.

37

Better breeding created more animals, which meant **MORE MEAT** and wool could be bought **AT LESS COST**.

41

The boom in crops brought new freedoms for farmers. Unlike in the European system, they had the **RIGHT TO WORK** for themselves and to rent, buy, or sell land.

43

Contracts spelled out what workers were expected to do and what they would **BE PAID**.

35

By carefully picking and choosing **ANIMALS** to breed, farmers created **BIGGER AND STRONGER** horses and camels.

38

Math, engineering, and astronomy **SKILLS** came in handy for figuring out water levels for **IRRIGATION** and charts for planting and harvesting crops.

44

As **OUTPUT GREW** every city came to have its own **MARKET GARDENS**, orchards, and fruit and olive plantations.

50

FACTS ABOUT FARMS to Feed On

15

HOT FACTS



1 It's believed that an Abyssinian **goat herder** in what is now Ethiopia discovered coffee **1,200 years ago** when his goats got an energy boost after eating some red berries. People soon began boiling the berries to make coffee.

2 People in parts of the Muslim world were sipping coffee as early as the **9th century**. The drink didn't catch on in Europe for another **700 years**.

3 **Travel and trade** spread the **popular drink** to Yemen, Mecca, Damascus, Baghdad, and Istanbul and to Europe and beyond.



4 Today more than **1.5 billion** cups of coffee are consumed around the world every day—enough to fill 300 Olympic-size **swimming pools**!



5 Ripe coffee beans are **red** and are called **coffee cherries**.

6 Coffee was just what some Muslims needed to help them **stay awake** during **late night prayers**.



7 **Cappuccino** coffee gets its name from the color of the robes worn by Christian **Capuchin monks**.

8 Coffee shops in England were nicknamed "**penny universities**" because you could listen to and talk with some of the greatest minds of the day for the **price of a cup of coffee**.

Modern cup of coffee



ABOUT COFFEE



9 “Mocha” is both the name of a kind of coffee bean and the name of the port in **Yemen** that was the center of the coffee trade from the 15th to 17th centuries.

10 In the mid-1600s coffee was brought to **New Amsterdam** (now New York, U.S.A.) by Dutch traders. A hundred years later coffee surpassed tea as the **favorite drink** in the future **United States**.

11 Today a **tall latte** (coffee with milk) is the most popular drink at **Starbucks**.



12 **Hawaii and Puerto Rico** are the only places in the United States where coffee can be grown.



13 In the Muslim world people drank their coffee **black**. Not until the 17th century did people start adding cream to their cups.

14 Coffee is now grown in **65 countries**, and it is the world's second **most traded** commodity after oil.

15 The world's first **coffee shop** opened in Venice, Italy, in 1645. By 1700 there were **hundreds** of coffeehouses in London, England, alone.





1 DESERTS COVERED LARGE PARTS OF the Muslim world. For people living in these dry and hot lands, the use and control of WATER WAS KEY TO THEIR SURVIVAL.



2 People in dry regions used water-raising devices, like the **EGYPTIAN SHADOOF**, a pole-and-bucket system, and the Roman waterwheel, or **NORIA**, and figured out ways to make **THEM BIGGER AND BETTER.**



3 16TH-CENTURY OTTOMAN ENGINEER TAQI AL-DIN IBN MA'ROUF SAID STEAM COULD POWER A TURBINE ENGINE ABOUT 100 YEARS BEFORE STEAM POWER WAS DISCOVERED IN EUROPE.

4 **MUHAMMAD AL-KARAJI**, AN 11TH-CENTURY MATHEMATICIAN AND ENGINEER FROM PERSIA (NOW IRAN) DESCRIBED A NETWORK OF UNDERGROUND TUNNELS CALLED **QANATS** THAT COULD CARRY WATER OVER LONG DISTANCES WITHOUT EVAPORATION.

5 TAQI AL-DIN'S 6-CYLINDER **WATER PUMP** HAD ALL THE FEATURES OF A MODERN-DAY 6-CYLINDER CAR ENGINE.

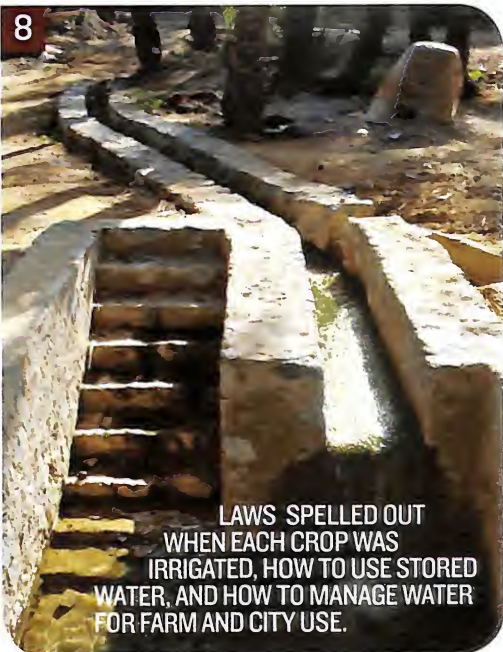
25

WATER



6 **QANATS** are still used to provide water to some areas in Iran and other countries in the Middle East.

7 QANATS HAD "MANHOLE" COVERS FOR AIR CIRCULATION AND TO HELP THE WATER FLOW THROUGH THE TUNNEL.



8 LAWS SPELLED OUT WHEN EACH CROP WAS IRRIGATED, HOW TO USE STORED WATER, AND HOW TO MANAGE WATER FOR FARM AND CITY USE.

9 LARGE **LANDHOLDERS AND STATE LEADERS** WERE RESPONSIBLE FOR DIGGING AND CLEANING QANATS AND REPAIRING DAMS.

10 SYSTEMS FOR DELIVERING **WATER** TO FARMS AND TOWNS HELPED IMPROVE QUALITY OF LIFE.

11 **AL-JAZARI** MADE THE FIRST MACHINE THAT COMBINED A **CRANK** AND CONNECTING ROD TO CONVERT CIRCULAR MOTION TO LINEAR MOTION.

12 Today **crank-rod** systems are used in everything from **CAR ENGINES** TO TOYS.

13 THOSE WHO BROKE A WATER LAW HAD TO FACE THE "TRIBUNAL OF THE WATERS," A GROUP OF OFFICIALS THAT DEALT WITH DISPUTES AMONG FARMERS.



14 TEN CENTURIES LATER THE **TRIBUNAL** STILL MEETS WEEKLY IN **VALENCIA, SPAIN.**

15

**SINCE
WATER
WAS SO
SCARCE,**
THERE WERE STRICT
RULES ABOUT THE
CARE AND USE OF
DAMS AND WATERWAYS.

16



ONE-THIRD OF ALL **DAMS** BUILT IN THE 7TH- AND 8TH-CENTURY MUSLIM WORLD ARE STILL STANDING.

17

Qanats and norias
were introduced to

SPAIN

when Muslims ruled Andalusia,
the southern part of the country.

18

THE INFLUENCE OF
Muslim civilization on
IRRIGATION

in Spain can be seen in certain
Spanish and Arabic words.

For example, the word for
"irrigation canal" in Spanish is
cequia, and in Arabic it is *sâqiya*.

FACTS TO TAP INTO

19

In the early
**13TH
CENTURY**

the engineer Al-Jazari,
from southern Turkey,
developed a brilliant way to
lift huge amounts of water—

**WITHOUT HAVING
TO LIFT A FINGER.**



20

**IN ALL, AL-JAZARI
DESIGNED FIVE
WATER-RAISING
MACHINES,**

including a water-driven pump that
sucked water up 39 feet (12 m) into
a system that was used to supply
water for irrigation and sanitation.

21



The **BASICS**
behind Al-Jazari's
pumps led to more sophisticated
modern developments, including
ARTIFICIAL HEARTS
and
BICYCLE PUMPS.

22

AL-JAZARI'S
PUMPS
REPLACED ANIMAL POWER WITH
GEARS AND WATER POWER.



23

LEONARDO DA VINCI is often
credited with developing
and using hydraulics
and **GEARS**, but his
work likely benefited
from the achievements
of earlier mechanical
GENIUSES.



24



IN THE VALENCIA AREA OF MUSLIM SPAIN YOU COULD ONCE
HAVE SEEN 8,000 **NORIAS** WATERING RICE PLANTATIONS.

25

ENGINEERS IN THE MUSLIM WORLD USED **TRIGONOMETRY, GEOMETRY, AND PHYSICS TO BUILD
ENORMOUS DAMS TO CONTROL FLOODS AND TO PROVIDE IRRIGATION.**

15

WINDMILL FACTS

1 Five hundred years before windmills appeared in Europe, they were a common sight in Asian Muslim lands.

2 Beginning in the 7th century windmills were used in the Muslim world for **grinding grain** and pumping water for **crops and gardens**.

3 One man's offer to build a mill driven by wind power, an idea that originally developed in Persia, led to the construction of the first known windmill in Arabia around 640 during the rule of Caliph Umar.



4 Windmills harnessed the power of the **steady winds** that blew regularly across Persia's dry deserts.

5 Al-Masudi, a 10th-century geographer, described Persia as a "country of wind and sand."

6 Wind power soon became widely used throughout Muslim civilization to run **millstones** for grinding corn, crushing sugarcane, and pumping water.



7 Early windmills were **two-story buildings** with as many as 12 fabric-covered, rectangular sails that turned on a vertical axis.



Medieval windmills in Campo de Criptana in Castilla La Mancha, Spain

TO BLOW YOUR MIND



8 Windmills were usually built on top of **castle towers**, hills, or platforms.

9 Wind towers on **rooftops** caught air and channeled it through homes, providing an early form of air conditioning.



10 **European windmills** looked very different. Instead of turning on a vertical axis, sails rotated on a horizontal axis like most do today.



11 You can still see the remains of ancient **vertical windmills** in Afghanistan.

12 Sails of ancient windmills were made from bundles of **palm leaves**.


13 Today **wind power** is a popular source of clean energy.

14 The biggest wind turbines generate enough **electricity** to supply about **600 U.S. homes** for a whole year.


15 Modern windmills—called **TURBINES**—can be as tall as a **20-STORY BUILDING** and have three 200-FOOT (60-M)-LONG blades.




1
A IS FOR **ADMIRAL**,
FROM *AMIR-AL BAHR*
("COMMANDER OF
THE SEAS").



2
B IS FOR **BARBICAN**,
FROM PERSIAN *BAB AL-*
KHANAH ("GATE HOUSE").



3
C IS FOR **CAVIAR**,
EITHER FROM FARSI
KAYA-DAR ("HAVING EGGS")
OR TURKISH *HAVYAR*
("FISH EGGS").



4
D is for **DRAGOMAN**,
from *tarjuman* ("TO INTERPRET"),
an interpreter or guide where Arabic,
Turkish, or Persian is spoken.

5
E IS FOR **ELIXIR**,
FROM *AL-'IKSĪR*
("PHILOSOPHER'S STONE").

26

WACKY

6
F IS FOR
FENNEC,
FROM *FANAK* ("DESERT FOX").



7
G IS FOR
GIRAFFE,
FROM *ZARAFĀ*.




8
H IS FOR
HAZARD, FROM *YASARA*
("PLAY AT DICE").

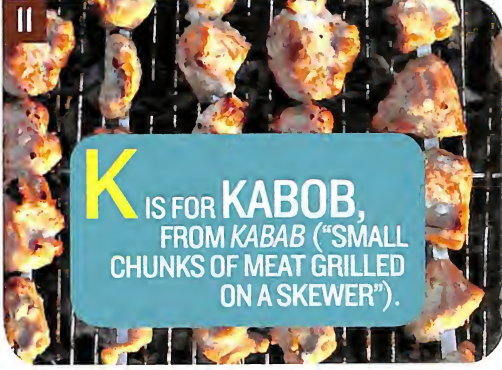


9
I IS FOR **IZAR**, FROM *AL-'IZAR*
("COVERING") THE NAME OF A STAR IN THE
CONSTELLATION BOOTES.

10
J IS FOR **JAR**, FROM *JARRAH*
("LARGE EARTHEN VASE").



11
K IS FOR **KABOB**,
FROM *KABAB* ("SMALL
CHUNKS OF MEAT GRILLED
ON A SKEWER").



12
L IS FOR **LILAC**,
FROM *LĪLAK*
("INDIGO").



13
M IS FOR
MUMMY,
FROM *MŪMIYĀ*
("EMBALMED
CORPSE").



14
N IS FOR **NADIR**,
FROM
NADHIR AS-SAMT
("OPPOSITE THE ZENITH").

15

O IS FOR **ORANGE**,
FROM *NARANJ*
("ORANGE").



16

P is for **PERKAD**,
from *al-farqadan* ("the calf"), a star in the
constellation Ursa Minor.

17

Q IS FOR **QANUN**,
THE ANCESTOR OF THE
HARP AND ZITHER,
INTRODUCED IN THE
10TH CENTURY.

18

R IS FOR
RACKET,
FROM *RÂH' ET*
("PALM OF THE HAND").

WORDS FROM THE PAST

From **ADMIRAL** to **ZERO** many words we still use today have ties to Muslim civilization. Here is a list of English words with roots in Arabic, unless otherwise noted.

19

S IS FOR
SO LONG,
FROM *SALAM*
("PEACE").

20

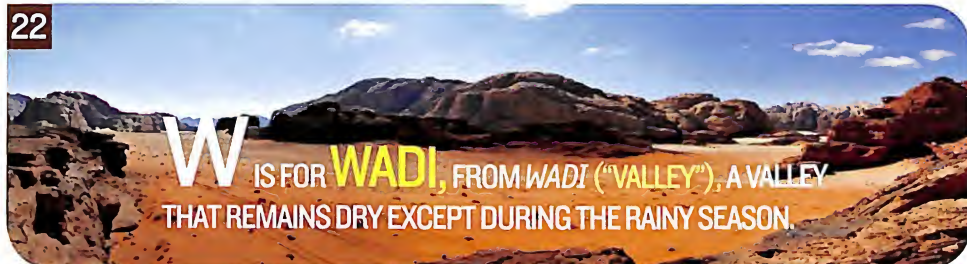


T IS FOR **TUNA**,
FROM *AL-TŪN* ("TUNA FISH").

21

U is for **UNUKALHAI**,
from *'unuq al-hayyah* ("neck
of the snake"), a star in the
constellation of the Serpent.

22



W IS FOR **WADI**, FROM *WADI* ("VALLEY"), A VALLEY
THAT REMAINS DRY EXCEPT DURING THE RAINY SEASON.

23

X IN **ALGEBRA**,
MEANING "A THING" (*SHAY*),
IS AN ARABIC INVENTION
TO SOLVE EQUATIONS.

25

Y IS FOR **YOGURT**,
FROM THE TURKISH *YOĞURT*.



26

Z IS FOR **ZERO**, FROM *SIFR* ("EMPTY").

24

V IS FOR **VIZIER**, FROM *WAZIR* ("PUBLIC SERVANT OR MINISTER").

GLOSSARY

Abbasid dynasty a dynasty that ruled the Muslim world between 750 and 1258 from Baghdad

Abyssinian a person from what is now Ethiopia

Al-Andalus Arabic name for Muslim-ruled Spain and Portugal; also called Andalusia

alembic name derived from Arabic for a glass container used in the distillation process

Allah the Arabic word for God

antipodes points on the Earth's surface that are directly opposite each other

Arab people originally from Arabia; can be of any faith

armillary sphere a group of rings centered on the Earth that represent celestial latitude and longitude and other features important to astronomical observations

astrolabe an ancient instrument for measuring the height of stars that was greatly improved upon during Muslim civilization; eventually replaced by the sextant

awqaf Arab word meaning "charity endowments"; public or private funds resulting from gifts or other kinds of donations

Bedouin a nomadic Arab desert dweller

B.C.E. acronym meaning "before common era"; C.E. means "common era."

Caliph a successor to the Prophet Muhammad who is a political, military, or administrative leader

celestial globe a globe that shows the stars, planets, and other heavenly objects in their relative positions in the sky

centaur a mythical beast with the head of a man and the body of a horse

clepsydra term for water clocks introduced in Egypt around 1500 B.C.E.

crop rotation the practice of growing different crops in different seasons on the same land

Crusades military expeditions undertaken by Christian armies from the 11th to the end of the 13th centuries to regain Jerusalem and other areas of the Holy Land from Muslims

Dark Ages another name for Middle Ages

dinar basic currency of the Muslim world; a gold dinar has about 4.5 ounces (125 g) of gold.

distillation process of purifying a mixture by heating it and then cooling it and collecting the substance produced by condensation

flax a plant grown for its seeds, which are a source of linseed oil, and its fibers, which are used to make thread for fabric.

hadith teachings of the Prophet Muhammad that are one of the major sources of Islamic law

hajj pilgrimage to Mecca, in Saudi Arabia

hammam a bathhouse

henna a reddish-brown plant dye most commonly used for making elaborate decorations on the skin

Islam the religion of Muslims, which recognizes Allah as the only god and Muhammad as the chief prophet

Ka'bah the sacred building in the center of the mosque at Mecca, Saudi Arabia

kiswa ornate cloth covering the Ka'bah

kulliye Arabic word meaning "complex." It referred to a learning center established by the Ottomans that included a mosque, school, hospital, and dining area.

light-year the distance light travels in one year (5,880,000,000,000 mi/9,460,000,000,000 km)

lunar year a period of 12 lunar months, each about 29.5 days

medieval referring to or characteristic of the Middle Ages

Middle Ages the period of European history between the fall of the Roman Empire and the Renaissance (approximately 500–1000 C.E.)

minaret the tower from which the muezzin, or crier, calls Muslims to prayer

miswak a twig from a tree that is used for cleaning teeth

mosaic a design made with small bits of colored glass, tile, or any similar object

mosque a public place of worship and prayer for Muslims

muezzin a person who calls Muslims to prayer

Muslim a follower of Islam; anything pertaining to Islam or Muslims

Muslim civilization a term referring to various cultures, faiths, and dynasties within the classical Islamic world (7th–17th centuries)

muwaqqit Arabic word for “timekeeper,” the wise man who determines the times of prayers based on observations of the sky

noria a large waterwheel that originated in ancient Rome

Ottomans a Turkish dynasty that ruled most of the Muslim world and parts of eastern Europe from 1299 to 1923

qanat an underground irrigation canal connected to the surface by wells

qitara an early form of guitar

quadrant an instrument representing a quarter of a celestial circle; used primarily for finding constellations

Quran sacred book of Islam, containing Allah’s revelations to the Prophet Muhammad; also spelled Koran

Ramadan a month of fasting that is the ninth month in the Islamic calendar

Rawdiya a genre of writing known as “garden poetry,” inspired by the love of greenery in the Muslim world

refraction the bending of a wave of light or other form of energy

Renaissance the period of European history characterized by a great revival of art, literature, and learning in the 14th through 16th centuries

sextant an instrument used by navigators for finding the distance between the horizon and a star

sidereal year the time it takes for the Earth to make a complete revolution around the sun

shadoof a pole-and-bucket system for raising water that originated in ancient Egypt

solar year the time it takes the sun to travel from one spring equinox to the next spring equinox; a year based on the seasons

soporific sponge a sponge soaked in ingredients designed to put a patient to sleep when inhaled before surgery

souk the marketplace

spolia the ancient practice of using building material from older structures to build new ones

staple a commodity that is in constant demand

Umayyad dynasty ruled from Damascus for about a century beginning in 661

universal astrolabe an astrolabe that could be used anywhere in the world

waqf an institution that manages charitable gifts and donations used to pay for mosques, schools, and various public services

wudhu’ the Muslim ritual of washing hands, face, feet, and other exposed parts of the body before praying

PERSONALITIES

Name: 'Abbas ibn Firnas

Vitals: Birth date unknown; died in 887; lived primarily in Córdoba, in Muslim Spain

Famous for: Creating a flying machine, glass from crystal, and a glass planetarium complete with artificial thunder and lightning!



Name: Al-Kindi

Vitals: Born about 801 in Kufa, Iraq; died about 873

Famous for: Making advances in math (he developed spherical geometry), music, and many fields of science (especially rocks and minerals), and translating books into Arabic.



Name: Al-Astrulabiya
(unconfirmed first name: Merriam)

Vitals: Born in 944; died in 967; lived in Aleppo, Syria, her birthplace

Famous for: Making very accurate astrolabes, complex devices that used the sun and stars to tell time and give directions. She was one of only a few women in Muslim civilization with this skill.



Name: Al-Zahrawi (or Abulcasis in Europe)

Vitals: Born in 936 near Córdoba, in Muslim Spain; died in 1013

Famous for: Describing more than 200 surgical instruments, writing a 30-volume encyclopedia about surgery and medicine, and pioneering the use of catgut for internal stitches.



Name: Al-Jazari

Vitals: Birth and death dates unknown, but he lived mostly in Diyarbakir in what is now Turkey, where he served the Artuq kings from 1174 to 1200

Famous for: Building clocks and water raising machines, and for designing mechanical devices like the crankshaft; using robotics; and writing his inventions manual, *The Book of Knowledge of Ingenious Mechanical Devices*.



Name: Fatima al-Fihri

Vitals: Born in the 9th century; died in 880; lived in Fez, Morocco

Famous for: Using her fortune to build a mosque and learning center in Fez that became so popular that students had to pass an entrance exam to earn a place. Classes are still held in Al-Qarawiyyin University.



FROM THE PAST

Name: Ibn al-Haytham (or Alhazen in Europe)

Vitals: Born in 965 in Basra, Iraq; died in 1039

Famous for: Experimenting with how the eye works, laying the groundwork for modern cameras, and writing the *Book of Optics*, which formed the foundation for the science of light and vision.



Name: Mimar Sinan

Vitals: Born in 1489 in Turkey; died in 1588

Famous for: Designing and building more than 477 mosques, schools, and other structures throughout the Muslim world while serving as chief architect for the Ottoman Sultans. Two of his most famous mosques, Selimiye in Edirne, Turkey, and Suleymaniye in Istanbul, have withstood earthquakes for more than 400 years.



Name: Ibn Battuta

Vitals: Born in 1304 in Tangier, Morocco; died around 1370

Famous for: Traveling more than 75,000 miles through 44 modern-day countries. The *Rihla*, which documents his travels, is one of the best eyewitness accounts of culture, customs, people, animals, and plants of the medieval world.



Name: Zheng He (also known as Hajji Mahmud Shamsuddin)

Vitals: Born in 1371 in Yunnan, presently a province of China; died in 1433

Famous for: Commanding a fleet of the largest wooden ships that had ever been built and transforming China into a world superpower by making seven monumental sea voyages. In 28 years he visited more than 37 countries!



Name: Jabir ibn Hayyan (or Geber in Europe)

Vitals: Born in 722 in Persia (now Iran); died in 815

Famous for: Devising and perfecting chemical processes such as distillation, evaporation, and crystallization, and for discovering sulfuric and hydrochloric acid.



RESOURCES

To learn more about the people and culture of Muslim civilization:

Books

*Al-Hassani, Salim T.S., ed. *1001 Inventions: The Enduring Legacy of Muslim Civilization*. 3rd ed. Washington, DC: National Geographic Society, 2012.

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Stone, Caroline. *Eyewitness: Islam*. New York: Dorling Kindersley, 2005.

Video and Websites

“1001 Inventions and the Library of Secrets,” short feature film at www.1001inventions.com/libraryofsecrets

www.MuslimHeritage.com (academic web portal; includes hundreds of articles and short reports related to Muslim heritage research, an interactive map, and a timeline)

www.1001inventions.com/education (Teacher’s guides, posters, and fun things for kids)

1001 Inventions Traveling Exhibit

Washington, DC—Explorers Hall, National Geographic Society, August 3, 2012–February 3, 2013

Check out other 1001 Inventions exhibitions coming to a city near you soon: <http://www.1001inventions.com>

About the Foundation for Science, Technology and Civilisation

The Foundation for Science Technology and Civilisation is a British based, non-profit, non-religious, non-political organisation. Founded in the United Kingdom in 1999, FSTC works with leading academics around the world to engage with the public through research work, educational media, conferences and events in order to highlight the shared cultural roots of science and technological inheritance of humanity. *1001 Inventions* was created by FSTC and launched in the United Kingdom in March 2006 to develop and deliver world class exhibitions and publications to further these aims.

1001 Inventions has successfully educated millions of people around the world through its blockbuster global touring exhibition, books, films, products, and educational resources.

1001 Inventions demonstrates that for a thousand years, from the 7th century onward, exceptional scientific and technological advancements were made within Muslim civilization. Men and women of various beliefs, languages, and backgrounds worked together and wrote hundreds of thousands of books, mainly in Arabic, building upon ideas of earlier worldwide scholars and making breakthroughs that helped pave the way for the European Renaissance.

Historians often interpret historical events differently. We have exerted all reasonable efforts to give an accurate portrayal of everything in this book. All of the content in this book has been researched and reviewed by a team of eminent historians of science. We strive to give the most accurate representation of everything that we can, and we are committed to the continuous improvement of our work. We encourage feedback to help us with this process. E-mail us at info@1001inventions.com.

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CREDITS

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